New Scientist

WEEKLY 19 February 2022

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could protect your heart

FUSION BREAKTHROUGH
New test gives best hope
yet of unlimited energy

PATHOGENS ON ICE
The viral threats hiding in
our thawing permafrost

MAKING A MIND

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artificial intelligence
that really thinks
like us

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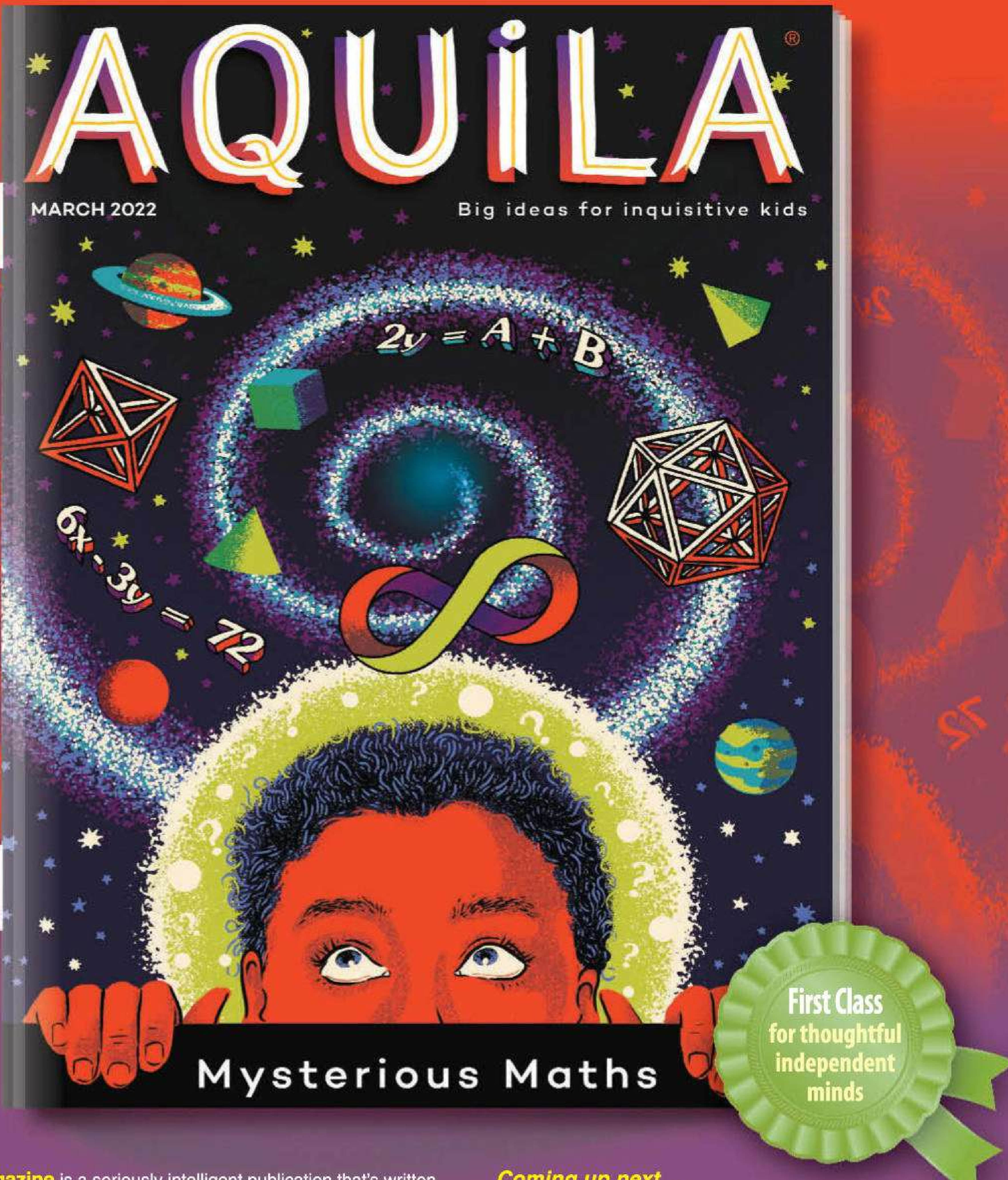
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Marine ecosystems of the Azores: Portugal

Explore the ocean life, lush vegetation, volcanic craters, lagoons and picturesque towns of these islands in the rich, biodiverse waters of the Atlantic. Accompanied by a team of experts, including marine biologist Jon Copley, you will spend time at sea and on land surrounded by a host of different species. This is an eight-day trip starting on 21 May.

newscientist.com/tours

Virtual event

The science of happiness

In this online talk, neuroscientist Sophie Scott will explore the natural history and the science of laughter, addressing its role in social bonding and play, as well as in emotion expression and communication. Join us online on Thursday 3 March from 6pm to 7pm GMT (1 to 2pm EST).

newscientist.com/events

Podcast

Weekly

We hear how three men paralysed from the waist down have regained their ability to walk, thanks to a breakthrough operation that involved implanting electrodes in their spines. Plus, how did a team of astronomers detect an isolated black hole for the first time? Meanwhile, the panel discusses major developments in the use of pig organs for transplants and a study that suggests dog faeces may be harming wildlife and biodiversity.

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REBECCA COLE/ALAMY

Pick it up Dog faeces might be harmful to wildlife and biodiversity

ROYAL GEOGRAPHICAL SOCIETY (WITH IBG)

Antarctic legacy Rare images of a famous expedition on show

Video

Shackleton's forgotten Antarctic images

More than 100 years after Ernest Shackleton's epic (but ultimately unsuccessful) Imperial Trans-Antarctic expedition, a new exhibition showcases some of the most iconic and rare images taken of the most southerly continent on Earth. Subscribe to our channel to get more explainers, discoveries and video reports each week.

youtube.com/newscientist

Newsletter

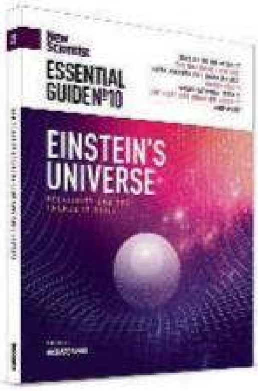
Lost in Space-Time

Get Richard Webb's musings on all things from cosmology to quantum mechanics sent direct to your inbox each month. The latest issue asks whether telling the time contributes to the heat death of the universe, takes a look at hints of new particles and mulls quantum-entangled tardigrades.

newscientist.com/lost-in-space-time

Newsletter

> **"Does telling the time add to the heat death of the universe?"**



Essential guide

How did the universe begin? What is it made of? Do black holes exist? Albert Einstein's space- and time-warping theories of relativity have revolutionised our view of the cosmos over the past century. Find out how in the 10th *New Scientist Essential Guide*, available now.

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GDF

New Scientist
Debate

FREE ONLINE EVENT

THE UK'S NUCLEAR WASTE AND THE GEOLOGICAL SOLUTION

Wednesday 23 February 2022 6pm GMT, 1pm EST and on-demand

The UK Government has decided that higher activity nuclear waste should be disposed of in a deep underground facility where scientists believe it can remain safe for the long term. Numerous countries have come to the same conclusion and work has already begun to create safe, secure and permanent disposal facilities elsewhere in the world.

This *New Scientist* debate brings together leading thinkers to explore the science behind the geological disposal of nuclear waste, examine the engineering, economic and social challenges at play and asks how similar projects elsewhere are faring.

Find out more and register your place:
newscientist.com/nuclearwaste

Panellists

Katherine Morris
BNFL Research Chair,
University of Manchester

Vesa Lakaniemi
Mayor of Eurajoki, Finland

Professor Penny Harvey
Professor of Social Anthropology,
University of Manchester

Professor Cherry Tweed
Chief Scientist for Geological
Disposal, Nuclear Waste Services

Justin Mullins
Consultant editor,
New Scientist and debate chair

Sponsored by Nuclear Waste Services

AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

Your Will can fund the rational response to health challenges that medical science provides.

> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

Changing medicine today.
Changing lives tomorrow.
medicalresearchfoundation.org.uk

"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

Please consider this very special gift today.

Professor Nick Lemoine CBE MD PhD FMedSci
Chair of the Medical Research Foundation

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Listen and learn

A collaborative approach is needed to avoid the next pandemic

HERE is a sinister idea: as climate change thaws the world's ice and permafrost, frozen viruses and bacteria may emerge and cause deadly outbreaks of ancient diseases (see page 46). We might one day have to face Neanderthal influenza or *Homo erectus* anthrax.

Most readers will, on balance, feel that we have had enough novel diseases lately. But the good news is that there is plenty we can do to reduce the chances of a major outbreak. Increased monitoring in remote permafrost zones, for example, will give public health agencies a chance to stamp out diseases before they gain a foothold.

So far, so positive. But if there is one lesson to be learned from the covid-19 pandemic, it is that having medical and technological solutions isn't enough. We also have to overcome social challenges.

Permafrost regions are often inhabited by Indigenous peoples who, owing to long histories of colonialism and genocide, are understandably mistrustful of the governments under which they live. That distrust often extends to scientific and medical institutions, which have been complicit in abuses. For these reasons, many Indigenous people are wary of covid-19 vaccines. The same problem may befall efforts to boost public health monitoring among the Indigenous communities living in permafrost zones.

> **"Indigenous community leaders must be involved in any public health projects from the outset"**

These problems aren't insoluble. In recent years, some researchers have tried to improve relationships with Indigenous groups. The result is an emerging body of knowledge on how scientists and doctors can work with Indigenous peoples to the benefit of all. One key principle is that Indigenous community leaders must be involved from the outset. For example, a project called FORGE AHEAD tackled the growing rates of diabetes among Canada's Indigenous peoples by working closely with communities to identify why they often didn't receive healthcare. It succeeded in boosting Indigenous people's access to diabetes therapy – which translated into better health.

Regardless of where the next potential pandemic comes from, it is this sort of collaborative, listening approach to research and public health that we need more of if we are to stop it before it starts. ■

PUBLISHING & COMMERCIAL
Commercial and events director Adrian Newton
Display advertising
Tel +44 (0)203 615 6456 **Email** displayads@newscientist.com
Sales director Justin Viljoen
Account manager Matthew Belmoh
Account manager Simon Matthews
Recruitment advertising
Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
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CONTACT US
newscientist.com/contact
General & media enquiries
UK Tel+44 (0)203 615 6500
Northcliffe House, 2 Derry Street, London, W8 5TT
Australia 58 Gipps Street, Collingwood, Victoria 3066
US PO Box 80247, Portland, OR 97280
UK Newsstand
Marketforce UK Ltd **Tel** +44 (0)33 0390 6555
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ARTUR WIDAK/NURPHOTO/SHUTTERSTOCK

A woman wearing a mask in Belfast, Northern Ireland

Covid-19

Removing restrictions

Countries worldwide are having to decide what "living with covid" really looks like, report **Alex Wilkins** and **Carissa Wong**

AS THE omicron variant continues to surge around the world, nations are having to face up to life amid continuing high infection rates. On Monday, Northern Ireland's health minister Robin Swann announced that the country's remaining legal covid-19 requirements were to become guidance instead from 15 February.

Northern Ireland isn't alone. Sweden and Denmark both lifted their pandemic restrictions earlier this month, despite daily infection rates in the tens of thousands. UK prime minister Boris Johnson is expected to announce a plan for "living with covid" for England on 21 February, which is likely to involve the end of isolation requirements for people who test positive for the virus.

But health advisers have warned that the pandemic and all its inherent risks – deaths from covid-19, chronic illness from long covid, higher risks to people who are immunocompromised and substantial pressure on hospitals – is far from over. "Immune-compromised patients remain at very high risk, higher risk than they've ever been before in their lives," says Lance Turtle at the University of Liverpool, UK.

Many nations are hoping that vaccination will make the difference. South Korea and Sweden have begun offering fourth doses of covid-19 vaccines to the clinically vulnerable.

But the UK has been slow to vaccinate its children. The US and Israel began offering vaccines to 5-to-11-year-olds in November 2021, and Australia and New Zealand have recently begun vaccinating this age group. The UK, in contrast, has only recently started offering covid-19 vaccinations to children aged 5 to 11 who are vulnerable or live with people who are immunocompromised.

The UK government was due to make an announcement on vaccinating all children in this age group on Monday, but this has now been postponed to 21 February. Writing in *The BMJ* last week, Christina Pagel at University College London and three other researchers described the UK as an international outlier for "not giving parents the *choice* of whether to vaccinate their child".

The US, meanwhile, has delayed a decision on whether to approve vaccination for children aged 6 months to 4 years. The US Food and Drug Administration had been due to decide on the Pfizer/BioNTech vaccine for this age group on 15 February, based on data from two doses in a clinical trial. However, the agency has now decided to wait for data from the third dose in this trial before making a decision on the vaccine's use in under-5s, which is expected in April.

While the omicron surge seems to have peaked in some countries, including the UK, the World Health Organization (WHO) noted on Tuesday that a wave of infections is now passing over eastern Europe, causing cases to double in multiple countries. The WHO warned that, as countries such as Poland consider lifting restrictions, the threat level remains high.

Omicron is also causing strain where authorities are pursuing zero-covid strategies. Daily infection numbers have repeatedly broken records in Hong Kong in recent weeks, numbering 2071 on 14 February. Hong Kong's chief executive Carrie Lam has said that the wave has "overwhelmed the city's capacity of handling".

While omicron may have shifted expectations for how nations can cope with covid-19 in the mid-to-long term, the prospect of further variants means there are no certainties. "A variant with any property could emerge at any time, and it could be totally different in terms of disease. It could be worse, could be better, could be the same, and that will happen at random," says Turtle. ▮

Medicine

The dream of ending child cancer

Is it possible to prevent all children dying from cancer? **Alice Klein** reports

TEK IMAGE/SCIENCE PHOTO LIBRARY

DNA sequencing helps offer a personalised approach to cancer

AN AMBITIOUS Australian programme to use personalised medicine to reduce the number of children who die of cancer to zero has already kept alive more than 150 children with aggressive cancers who would have otherwise died. The success of the scheme – the Zero Childhood Cancer Program, or Zero – means it will be made available to all Australian children with cancer from 2023.

One of Zero's participants is Jack Burai in Sydney, who was diagnosed with a brain tumour in 2017, when he was 9 years old. His cancer was surgically removed, but came back aggressively a year later and spread through his brain and spine, leaving him unable to walk, eat or see out of his right eye. "It was an end-of-life situation," recalls his father Alex. "When his mum was out of the hospital room, he would turn to me and say, 'Dad, am I going to die?'."

Now, Jack is a healthy, seemingly cancer-free 14-year-old who runs marathons and rides his BMX bike daily thanks to the personalised care he received through Zero. The idea of the programme is to move away from giving standardised treatments and to view every child's cancer as unique, says Chelsea Mayoh at the Children's Cancer Institute in Sydney, where Zero is based.

The first step is to try to work out more about each child's cancer. To do this, Mayoh and her colleagues genetically sequence a child's tumours and run other tests. Once the possible drivers are identified, the team searches medical literature and talks to colleagues to determine what sort of treatment might work best.

The team also tries a scattergun approach by testing more than 100 different cancer drugs on tumour cells taken from the child and grown in Petri dishes. Drugs that seem most active against the cells are then tested in mice that have been injected with the child's tumour cells to check their safety and efficacy before they are given to the child.

In Jack's case, genetic sequencing showed that a mutation called V600E in a gene called *BRAF* was driving his cancer. The Zero team knew that cancers with this mutation often respond to drugs called dabrafenib and trametinib and recommended them to his oncologists.

Within a week of taking these drugs, Jack was walking again, and after four weeks, he was playing tennis. Scans showed the tumours in his brain and spine rapidly shrinking, before disappearing altogether. "It was truly miraculous because he had been slipping away in front of our eyes, and then he was suddenly back to his normal self," says his mother Viv.

Zero is the brainchild of Michelle Haber, the executive director of the Children's Cancer Institute. In 2013, she convened several cancer experts and explained her idea for the personalised medicine scheme. "They told me I was nuts, but they agreed to give it a go," she says.

After securing A$20 million (US$14 million) of funding from the Australian government, the team started by enrolling children with cancers that give people a less than a 30 per cent chance of survival, like Jack's. "These are the children whose parents are told, 'Go spend some quality time together'," says Mayoh.

Since 2015, 700 children have joined Zero from children's cancer hospitals in Australia. Individual cancer drivers have been identified for 94 per cent of them and targeted treatments have been recommended for 72 per cent.

Of the children who have had targeted treatments, 31 per cent have responded, meaning their cancers have partially or completely disappeared or stabilised, says Mayoh, who will present the results at the annual scientific meeting of the Royal College of Pathologists of Australasia next month.

With standard care, these children would have died, says Mayoh. "We always said that helping just one patient would be amazing, so we think it's been a huge success." Because the treatments in Zero are targeted, they also tend to have fewer side effects than conventional therapies, says Mayoh.

700

Number of children who have joined the Zero cancer programme

72%

Proportion of those children recommended a targeted therapy

31%

Proportion of those treated whose cancers shrunk or were stabilised

Jack Burai was diagnosed with a brain tumour when he was 9 years old

VIVIAN ROSATI

A faster approach

Zero hasn't been able to save every child, often because they succumb to their disease before a personalised treatment can be found. The team has managed to cut the time it takes from sequencing a child’s tumour to giving them a personalised treatment from 12 to six weeks on average, and hopes to get it down to four.

The programme currently costs A$10,000 per child for the tumour sequencing and analysis, plus extra for the studies in cells and mice and the drugs that end up being prescribed.

Other countries are experimenting with personalised medicine programmes for children with cancer, but Zero is the most comprehensive to date, says Mayoh. “I think it’s only a matter of time before other countries follow.”

> “When his mum was out of the hospital room, he would turn to me and say, ‘Dad, am I going to die?’”

Zero was recently named by the US National Advisory Council for Human Genome Research as being one of the top 10 accomplishments in genomic medicine implementation.

The scheme has also now secured another A$55 million from the Australian government to make it available to every Australian child with cancer from next year, not just those with the worst cancers.

Haber is confident we will get to a point where zero children die of cancer, especially as new immunotherapies and other treatments become available. “In the 1950s, cancer was a death sentence for children, and now the survival rate is over 80 per cent,” she says. “I do think that personalising treatments – making sure you get the right drug for the right child at the right time – will get us towards our goal of one day curing all children of cancer.” ▮

Astronomy

Rare ‘hyperburst’ is powerful nuclear explosion in space

Jonathan O’Callaghan

ASTRONOMERS think they have found evidence for an extremely powerful nuclear explosion in space – one so rare that we are unlikely to ever see its like again.

The explosion seems to have taken place inside a strange neutron star located 140,000 light years from Earth called MAXI J0556-332. Neutron stars are the remnant cores of larger stars that have exploded in supernovae, leaving city-sized objects that contain up to twice the mass of our sun. MAXI J0556-332 was discovered in 2011, paired with another larger star. It has confused astronomers ever since, as it was twice the normal temperature of neutron stars when it was first spotted, though it has since cooled.

Now we might know why. Dany Page at the National Autonomous University of Mexico and his colleagues think a huge and unstable thermonuclear explosion may have taken place inside the neutron star. The event, which they dub a “hyperburst”, was so deep inside the star it was undetectable. It would have caused significant heating, explaining the gargantuan spike in temperature (arxiv.org/abs/2202.03962).

“Finally, we have a physical explanation why it is so hot,” says Page. “Everything makes sense.”

Neutron stars in pairs like this can gain material from their companion star, sucking huge amounts of gas onto their surfaces. This process makes the neutron star very hot, and can also result in detectable bursts near the surface when hydrogen and helium burn, which can happen as frequently as every few minutes. More powerful bursts, known as superbursts, occur every few years as heavier carbon is burned about 100 metres below the surface of the neutron star, releasing 100 times more energy than a regular burst.

The team’s modelling suggests hyperbursts would be 100 times stronger still and occur 500 metres below the surface, deep inside the ocean of thick plasma that encompasses neutron stars. They would result from the burning of oxygen, which would build up to eventually “generate more energy than can be leaked away”, says Page, with temperatures approaching 400 million °C. The result would be an explosion that released more energy in a matter of milliseconds than our sun does in 100,000 years – but it would be undetectable from outside the neutron star because of its depth.

Pushing enough matter into the neutron star to drive this explosion, however, would take a long time. “You have to wait for maybe 1000 years,” says Page. The neutron star must also have stopped gaining material from its companion in order for the temperature of the explosion to be noticeable, something only seen in a handful of binary neutron stars. This rare combination of circumstances means this might be the only hyperburst we ever witness. “We’re lucky to have one,” says Page.

Anna Watts at the University of Amsterdam says it is a “really interesting idea”, noting that previous attempts to explain this neutron star’s unusual temperature relied on a “hand wavy” idea called shallow heating. This suggested there was some sort of heating process taking place in the crust of the neutron star, but the science was uncertain. “A hyperburst would certainly solve the energy problem,” says Jean in ’t Zand at the Netherlands Institute for Space Research.

There might be an unusual way to test the idea: by never observing a hyperburst again. This would suggest Page’s idea for their rarity is correct. “You just really hope they don’t find another one now,” says Watts, a somewhat strange wish for a potentially new astronomical discovery. ▮

An artist’s impression of a large explosion in space

SHUTTERSTOCK/MIK ULYANNIKOV

Climate change

Lichens may take a million years to adapt to 1°C of global warming

Jake Buehler

ONE of life's most important symbiotic partnerships may be threatened by a warming climate.

Lichens – a composite organism made from cyanobacteria or algae entangled within the body of a fungus – may be evolutionarily outpaced by changing climatic conditions thanks to a slow rate of evolution in the algal component of the ancient collaboration.

> **"What is the generation time of an organism that can essentially live forever?"**

Matthew Nelsen at the Field Museum in Chicago and his colleagues have been investigating how the climatic preferences of the lichen algae have changed over evolutionary time, and how this relates to what the algae are facing with ongoing climate change.

The team focused on a single genus of algae, *Trebouxia*, which is found in about 7000 species of lichen. For comparison, there are only about 6400 described mammal species on Earth today.

"It really puts it in perspective that this is quite a lot of diversity these algae are responsible for maintaining," says Nelsen.

The team collected data on where *Trebouxia* occurs across the world, and noted the climatic conditions at each location. The group also used a database of *Trebouxia* genes to create a global family tree for the algae, to reveal which forms were ancestral to the others. Using all of this information, Nelsen's team could estimate how rapidly *Trebouxia* – and the lichens it lives within – have adapted to changing climates in the past.

The team found that the algae were slow to adapt to new climates, shifting average temperature preferences by less than 1°C every million years. This rate is "substantially lower" than the 1°C to 4°C global temperature rise predicted over the next 80 years or so, says Nelsen (*Frontiers in Microbiology*, doi.org/hgwh).

"It's just really disheartening to see actual numbers and data showing how discordant these two rates are: the predicted rate of global climate change, versus the rate at which [preferences] changed in the past," says Nelsen.

MATTHEW NELSEN

A lichen in the Atacama desert that contains *Trebouxia* algae

James Lendemer at the New York Botanical Garden says that having a longer generation time could make rapid evolution less likely, and that lichen biology may partially explain the slow pace of evolution.

"What is the generation time of an organism that can essentially live forever, in many ways?" says Lendemer.

Nelsen predicts that lichens that depend on *Trebouxia* will disappear from many of the places they are found in today, although there may also be some migration to locations with tolerable temperatures and humidity.

Their disappearance could have far-reaching ecological impacts. Lichens play crucial roles in soil stabilisation and moisture retention and can serve as food or shelter to animals. ▮

Military technology

Microwave weapon lets drones shoot down other drones

A MICROWAVE weapon that can be carried by a drone is powerful enough to shoot down other drones and can also knock out other electronic devices.

The Leonidas Pod, produced by start-up Epirus based in Los Angeles, generates a beam of microwaves to overload a target's electronics, causing drones to drop out of the sky.

Other counter-drone microwave weapons are based on magnetrons, the technology found in microwave ovens, and are the size of a shipping container. Instead, Epirus uses compact solid-state emitters and last year unveiled a device that can fit on a pickup truck.

The new device is roughly the size of a microwave oven and weighs less than 24 kilograms. Epirus hasn't revealed the range of the weapon, but says its beam can be shaped as needed, firing a broad fan to tackle a swarm of drones or a narrow beam to pick out a specific target. It can also put computers, radios and vehicle electronics out of action. "We do anticipate the system being used for additional EW [electronic warfare] and counter-electronics missions," said a spokesperson for Epirus.

EPIRUS

The Leonidas Pod is small and light enough to be carried by a hexacopter drone

The makers stress that the device doesn't affect people, and has been validated as safe by National Technical Systems, an independent testing agency.

The cost of the system is likely to be a significant factor in how widely it is used. "Placing a RF/HPM [radio frequency/high-power microwave weapon] on a drone is going to be pretty costly unless breakthroughs in getting energy to the weaponry have been made," says Robert Bunker at C/O Futures, a US-based security consulting firm. ▮

David Hambling

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Social media

Facebook anti-vaccine policy worked briefly

Chris Stokel-Walker

POLICIES put in place by Facebook to tackle covid-19 vaccine misinformation had a meaningful impact on the amount of negative conversation around jabs – but only temporarily.

David Broniatowski at George Washington University in Washington DC and his colleagues used CrowdTangle, a tool belonging to Facebook's owner Meta, to analyse anti-vaccine conversations on Facebook before and after the platform made policy changes. These were introduced between November 2020 and February 2021 and included removing posts that could lead to harm, such as false claims that covid-19 vaccines contain microchips.

The researchers identified 216 Facebook pages and 99 Facebook groups conducted in English where discussions about vaccines regularly took place. A Facebook page is often run by an individual or organisation to predominately broadcast to users, while a group more often hosts discussions between users. Two-thirds of the pages and groups the team identified were opposed to covid-19 vaccines, based on descriptions written by moderators.

24%

of anti-vaccine groups closed after Facebook's policy changes

Every public post made on those groups and pages in the 12 months prior to November 2020 was extracted, along with the levels of engagement with them. The same pages and groups were revisited in August 2021 – after policy changes – and all public posts made in the previous six months were extracted and analysed. In total, more than 350,000 posts were gathered from these groups and pages. A further 266,000 posts were analysed from groups and pages that appeared between November 2020 and August 2021.

After revisiting, the team found that 13 per cent of pages and 24 per cent of groups in the original sample disappeared. A further 5 per cent of groups changed their privacy setting to private, preventing further analysis.

In those groups and pages that remained, the volume of posts and interactions decreased, indicating Facebook had some success in tackling vaccine disinformation. On anti-vaccine pages and groups, posts decreased to 29 per cent and 60 per cent of pre-policy levels and engagements dropped to 23 per cent and 66 per cent of pre-intervention levels, respectively. (arxiv.org/abs/2202.02172). However, the number of posts and engagements on pages promoting vaccines dropped, too, though not by as much. The team says this content may have been caught up in the dragnet.

The effect was short-lived. After six months, new posts on pages returned to 82 per cent and engagements to 80 per cent of their pre-policy level, while in groups, posts were 8 per cent higher than before the policy and engagements were 312 per cent higher. While the team is still analysing why this happened, Broniatowksi believes that users making anti-vaccine posts may simply have found a way around the policy.

A spokesperson for Meta says: "There were many other changes happening during this period which could have played a role in these results, which the research doesn't take into account." Meta says this could include the roll-out of covid-19 vaccines, and how the tone of discussions around them changed over time. ▮

Climate change

'Cold blob' may be slowing loss from Iceland's glaciers

Jason Arunn Murugesu

GUITAR PHOTOGRAPHER/SHUTTERSTOCK

Skaftafellsjökull glacier in Vatnajökull National Park, Iceland

ICELAND'S glaciers are melting more slowly than expected because they are close to a "cool blob" of water in the North Atlantic Ocean.

Brice Noël at Utrecht University in the Netherlands and his colleagues devised a model to reconstruct the shrinking of Iceland's glaciers between 1958 and the present day. The model was based on regional data from the surrounding North Atlantic, as well as atmospheric data and information from the glaciers themselves.

The researchers discovered that Iceland's glaciers – which cover about 10 per cent of the country – started melting more quickly around 1995. But, in line with previously published work, they found that this rate of loss slowed after 2011.

"Iceland was losing 11 gigatonnes of ice a year, but losses have halved since 2011"

"We already knew Iceland's glaciers were melting slower from satellites, but with this model, we could link this to the development of a cool blob in the ocean," says Noël.

This "cool blob" is a spot in the North Atlantic, just south of Greenland, which is particularly cold. "We don't have conclusive evidence for what caused this blob or how big it really is as it's always fluctuating," says Noël.

The researchers estimate that, before 2011, Iceland was losing about 11 gigatonnes of ice a year, whereas after this date, the losses have been about half this figure.

The researchers' model predicts that the blob will keep cooling Iceland's glaciers until about 2050, when it will dissipate. At this point, the glaciers will start melting more quickly again (*Geophysical Research Letters*, doi.org/hgnb).

By 2100, the island's glaciers will have lost the same amount of volume as they would have done regardless of whether the cool blob in the North Atlantic existed or not, according to the model's prediction.

Noël says the key to slowing the rate of ice loss is curbing climate change. "If we stop warming so much in the second half of the century, then we can conserve these glaciers for longer," he says. ▮

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Wildlife Aid Foundation**

British wildlife in crisis

A quarter of native British mammals are now at risk of extinction and the UK, with just 53 per cent of its biodiversity remaining, is listed as one of the world's most nature-depleted nations.

In the coming months the struggle for survival faced by much-loved species such as hedgehogs, foxes, badgers and songbirds will become increasingly acute as breeding season in the wild begins. Dens and burrows will be disturbed by unwitting humans. Nursing mothers will die in road accidents. Nests will be destroyed by gardeners. Young will be abandoned. There is a good reason why the wildlife fraternity describe spring as "orphan season".

For the last 40 years, the Wildlife Aid Foundation has rescued, rehabilitated and released British wildlife. Each year it responds to over 20,000 incidents. Orphan season is its busiest. During the next months, the charity's state-of-the-art wildlife hospital will operate round-the-clock, caring for thousands of patients. Its work will also help other wildlife centres: as a centre of excellence for UK wildlife care, the hospital trains veterinarians and wildlife carers in the vital skills and protocols needed to ensure that orphaned and injured wildlife get the best possible chance of release back into the wild.

The last two springs have seen unprecedented numbers of patients. Lockdown and work-from-home undoubtedly played a part as more people spent time outdoors enjoying nature. Climate change is also a factor. Breeding patterns have changed noticeably, with animals breeding earlier each year.

To provide this level of care, Wildlife Aid Foundation relies on over 300 volunteers and the generosity of the public as it receives no statutory funding and frequently takes in patients from better funded organisations such as the RSPCA. During orphan season the charity's running costs increase to over £20,000 a week.

Yet many of the incidents the charity responds to can be avoided, as CEO Simon Cowell explains: "We always urge people to think about wild animals before they start work on their gardens and homes and the advice is particularly relevant this time of year when there is young around."

Want to help?

For more information on how you can help British wildlife and support the work of Wildlife Aid Foundation, visit www.wildlifeaid.org.uk

Xenotransplantation

Pig organ trials may start soon

After completing a human trial of modified pig skin grafts last year, a team in China hopes to start the first pig organ transplant trial, reports **Michael Le Page**

SEVERAL groups are vying to be the first to transplant organs from genetically modified pigs into people as part of a clinical trial. One of the contenders is a team in China that last year was the first to complete a human trial of CRISPR genome-edited pig skin grafts.

"We plan to do heart or liver xenotransplants within 2022, but we do not have a specific timetable at this moment," says Lijin Zou at the First Affiliated Hospital of Nanchang University in China.

"We are completing all the technical and medical preparations, including the preparation of surgeons and the ICU team for solid organ xenotransplants," he says. "We are in the middle of seeking all the necessary approvals."

Teams around the world are genetically modifying pigs to make their organs less likely to be rejected by the human immune system. Zou's team has removed three genes from a strain of miniature pig and added eight human genes. The changes are similar to those made to the pig whose heart was transplanted into David Bennett at the University of Maryland School of Medicine on 7 January. This transplant, which made headlines worldwide, was done as a last resort rather than as part of a trial. The pig came from a line created by US firm Revivicor.

Last year, Zou's team carried out a clinical trial involving 16 people with burns. With severe burns, it is often necessary to temporarily cover the wounds with skin from human cadavers or pigs to prevent infection and the loss of fluid and to help prepare the site for a skin graft taken from elsewhere on the body.

In the trial, each person had a "Xeno X" skin graft from the modified pigs placed alongside a material derived from unmodified pigs. No drugs were given to stop their bodies rejecting the grafts.

The material from unmodified pigs never linked up with blood vessels in the human tissue to get a blood supply, and lasted just eight days. Skin from human cadavers also typically lasts eight days when used in this way.

The skin from the modified pigs quickly developed a blood supply. The grafts did start to be rejected, as expected, but survived for 25 days, after which they were removed. None of the people treated had any adverse reactions or developed infections (medRxiv, doi.org/hgmp).

"It might eventually be possible to create pigs whose skin looks and functions like human skin"

"Our unprecedented work demonstrates that the Xeno X skin could be an effective treatment for severe burns, particularly when human cadaveric skin is in short supply," says Zou.

Other researchers say that the results are encouraging. "The availability of a modified xenograft that lasts longer could be of significant benefit to patients with large and deep wounds," says Adam Singer at Stony Brook University in New York.

Zou says his team will now expand the trial and include people with life-threatening burns. The team is also making further genetic changes to pigs to improve the skin. It might eventually be possible to create pigs whose skin looks and functions just like human skin for long-term replacement, he says.

The team also hopes to get the go-ahead to transplant organs from modified pigs into people about to die while waiting for a human organ. Initially, the pig organs would be a temporary measure, to be replaced by ones from humans. The team is likely to start with heart transplants.

"The Chinese project looks promising," says Herbert Haller at the Trauma Hospital Berlin in Germany. But long-term trials need to be done, he says.

Several groups in the US are also awaiting approval to commence such trials. Muhammad Mohiuddin at the University of Maryland School of Medicine, whose team transplanted the Revivicor pig heart into Bennett, says his team is seeking approval for a clinical trial from the US Food and Drug Administration (FDA).

"However, the FDA wants us to do further non-human primate studies before they give us this permission," says Mohiuddin.

Hearts from normal-sized pigs can grow too large after being transplanted. In the pig line that provided the heart for Bennett, Revivicor has deleted a gene for a growth hormone receptor to try to prevent this. Zou thinks his team's use of miniature pigs will prove to be an advantage in this regard.

In 2021, two teams temporarily transplanted Revivicor pig kidneys into people diagnosed as brain dead, and at least one of the teams aims to start clinical trials soon. "We are very hopeful that we would be able to implement a phase I trial later this year," said Jayme Locke at the University of Alabama at Birmingham at a press conference on 20 January. "We do have a herd of pigs that would be ready."

Also in the race is a US company called eGenesis that has, in collaboration with a Chinese firm called Qihan Biotech, created pigs with even more extensive changes than those modified by Zou's team and Revivicor.

"We are meeting with the FDA in the middle of this year for both our kidney and [insulin-producing] islet cell programmes," says a spokesperson for eGenesis. "With their guidance, we will move our programmes into the clinic as quickly as possible."

Neither Qihan Biotech nor a US xenotransplant company called Makana Therapeutics, part of bioengineering firm Recombinetics, responded to questions about their plans for clinical trials.

PEGGYCHOUCAIR/PIXABAY

Pigs could be genetically engineered to provide transplant organs

Archaeology

Modern humans moved into cave one year after Neanderthals abandoned it

Michael Marshall

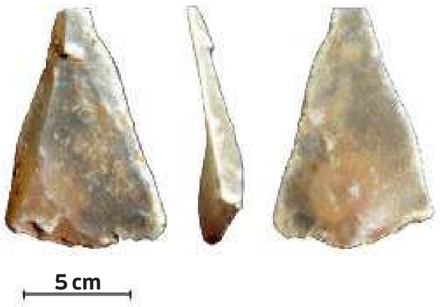
A SMALL group of modern humans lived in what is now France about 54,000 years ago. This is 10,000 years before our species began spreading across Europe in earnest. The pioneering group moved into a cave that had been abandoned by Neanderthals just a year earlier, and lived there for about 40 years, before disappearing.

"It's not just one wave of modern humans arriving and colonising all Europe, there are probably several attempts," says Clément Zanolli at the University of Bordeaux in France. "What we have found… is probably one of those attempts, and there are probably other attempts that we did not find yet."

It isn't clear why this incursion into Europe was unsuccessful. "Did they go back to where they came from?" asks Zanolli. "Or did they just die there and not survive more than a few decades? It's impossible to say."

Zanolli is part of a team that has been excavating at Grotte Mandrin in southern France since 1990. It is a small cave on a hill, overlooking the Rhône valley. Over the years, the team has found nearly 60,000 stone artefacts and more than 70,000 animal remains. Crucially, there are also nine hominin teeth, from at least seven individuals.

SLIMAK-METZ



Excavations at Grotte Mandrin (left) and three views of a modern human stone tool found there (above)

The team has used these artefacts, along with dating techniques, to reconstruct which hominins lived in Mandrin. The earliest known inhabitants were Neanderthals, who lived there from more than 80,000 years ago until about 54,000 years ago.

However, one of the teeth belonged to a modern human. The layer of sediment in which it was found was dated to between 56,800 and 51,700 years ago, probably about 54,000 years ago. The stone artefacts found in this layer were different from those associated with the Neanderthals, and resembled those made by modern humans elsewhere.

In younger layers of sediment, the team again found Neanderthal remains. Signs that the cave was being used by modern humans reappeared after 44,100 years ago.

The first switch from Neanderthals to modern humans happened quickly, says co-author Ludovic Slimak at the University of Toulouse-Jean Jaurès in France.

"Between the last fire in the cave by Neanderthals and the first fire in the cave by *Homo sapiens*, it's something like a year maximum time," he says. The team could tell this from studying pieces of soot from fires, on which layers of calcite had formed that could be precisely dated. The soot and calcite evidence also helped to pin down the length of time for which the cave was occupied by modern humans to roughly 40 years (*Science Advances*, DOI: 10.1126/sciadv.abj9496).

The results are "convincing", says Katerina Harvati at the University of Tübingen in Germany and show "the complexity of the process of dispersal and contact".

Zanolli's team found no evidence of cultural exchange between the groups. Yet given that the two groups were in Mandrin in successive years, "it's very likely that they met", says Zanolli. ▮

Animal behaviour

Spiderwebs may be the world's most sensitive 'ears'

SOME spiders can pick up sounds in the air using their webs as acoustic antennae, and because the spider silk responds so precisely to vibrating air molecules, the webs may act as the most sensitive "eardrums" in the natural world.

We already know that spiders can detect prey tangled in their webs by sensing vibrations in the silk using touch organs around their leg joints.

Now, Jian Zhou at the Argonne National Laboratory in Illinois and his colleagues have found evidence that bridge spiders (*Larinioides sclopetarius*) can use their webs to sense sounds travelling through the air from several metres away. The team placed 60 bridge spiders in glass chambers containing wooden frames on which the spiders wove their circular webs.

The group then played sounds with a frequency of 200 hertz – similar to those made by buzzing insects – at each spider and its web for 3 seconds, from loudspeakers located 3 metres away. Over the next few seconds, 90 per cent of spiders responded, by crouching, for example, suggesting that they had detected the distant sounds.

SHUTTERSTOCK/DAN OLSEN

A female bridge spider (*Larinioides sclopetarius*)

By projecting sounds either from the left or the right of the webs, the team found that some of the spiders could even sense where the noises were coming from. Five out of 12 tested spiders pivoted towards the direction of the sound source (bioRxiv, doi.org/hgm8).

Using a laser to map the nanoscale movements of the webs as sounds were played at them revealed that the silk strands could move at the same speed as the air molecules immediately around them, transmitting the full array of frequencies tested. This makes the webs far more sensitive than all known animal eardrums, which, as membranes, respond instead to bulk sound waves in the air. ▮

Carissa Wong

Health

Yoga at least once a week may help to lower blood pressure

Alice Klein

PEOPLE with high blood pressure may benefit from practising yoga, according to a large observational study carried out in the US.

About one-third of adults globally have high blood pressure, which increases the risk of having a heart attack or stroke. Physical activity is known to lower blood pressure not only during heartbeats (systolic pressure) but also in between beats (diastolic pressure). However, many people have trouble sticking to exercise regimes.

DEEPOL BY PLAINPICTURE

Yoga tends to be more sustainable than many other forms of exercise because it is gentle on the joints, can be done with others and helps to relax the mind.

Several clinical trials have found that yoga lowers blood pressure, especially when it incorporates breathing exercises and meditation. But it has been unclear whether these results translate to real life.

To find out if yoga helps to reduce blood pressure in real-world settings, Nadia Penrod at the University of Pennsylvania and Jason Moore at the Cedars-Sinai Medical Center in Los Angeles studied the electronic health records of 1355 people aged 18 to 79 in south-east Pennsylvania whose clinical notes said they practised yoga at least once a week.

"Even a modest fall in blood pressure across a population would prevent many strokes"

They compared each of these people with at least three other individuals who had similar characteristics in terms of age, sex, race, postal code, body mass index, alcohol use, smoking status and use of blood pressure-lowering medications, but who had no mention of practising yoga in their clinical notes.

On average, the people who practised yoga had a systolic blood pressure that was 2.8 millimetres of mercury (mmHg) lower and a diastolic blood pressure that was 1.5 mmHg lower than those who didn't do yoga (*BMC Public Health*, doi.org/hgj4).

This reduction probably wouldn't make a massive difference to most people in the study, since they tended to be young, healthy women who already had normal blood pressures, says Mark Nelson at the University of Tasmania in Hobart, Australia.

However, if average blood pressure declined by this much across a population, it would prevent a significant number of heart attacks and strokes, he says.

For example, a 2015 study discovered that reducing the systolic blood pressure of all middle-aged adults in the US by an average of 2 mmHg would prevent more than 12,000 heart attacks and 7000 strokes each year.

There could be real-world health benefits to yoga

Based on the latest study, we can't say for sure that yoga lowers blood pressure because there may be other explanations for the findings, says Geoff Head at the Baker Heart and Diabetes Institute in Melbourne, Australia.

For example, people who do yoga may have lower blood pressure because they tend to have better diets, not because of the yoga itself, he says.

It is also important that yoga isn't seen as a substitute for blood pressure-lowering medications, which typically reduce systolic blood pressure by more than 5 mmHg, according to Head.

Nevertheless, yoga is likely to assist with lowering blood pressure if it encourages exercise-shy people to start moving, says Nelson.

"The greatest benefit is getting the sedentary to do something rather than increasing exercise in someone who does it regularly," he says. ▮

Military technology

US Army supplier to ditch depleted uranium rounds

David Hambling

THE maker of a controversial depleted uranium weapon used by the US Army has said that it is ceasing production of the munition.

Depleted uranium (DU) is an extremely strong and dense metal that is able to pierce armoured vehicles, making it the prime choice as the chief anti-tank ammunition used by the M1 Abrams, the US Army's main battle tank. However, it is toxic and radioactive, and campaigners linking DU to cancer and other health issues have long called for it to be phased out.

That may now happen. During a quarterly earnings update on 27 January, Kathy Warden, the CEO of defence company Northrop Grumman, unexpectedly announced that the firm will stop producing the M829A4 DU round within a year.

"We are looking to the future and the decision to cease production boils down to sustainability," Jarrod Krull at Northrop Grumman told *New Scientist*. He declined to explain further, but said the decision wasn't made for financial reasons.

The DU component used in the anti-tank round is produced for Northrop Grumman by another firm, Aerojet Rocketdyne, and it is unclear if it will continue to do so. The US Army put out a request for an alternative supplier in January.

Only the UK and US have admitted using DU rounds in action, but other nations, such as Russia, have them. Some have long renounced them – Belgium banned them in 2009. "Generally, the battle to stigmatise depleted uranium has been won," says Doug Weir at the Conflict and Environment Observatory, a UK non-profit organisation.

The scientific consensus is that the risk to surrounding populations from DU is low, but Weir says the weapons now appear to be in a category with cluster bombs and land mines as being unacceptable for some investors. ▮

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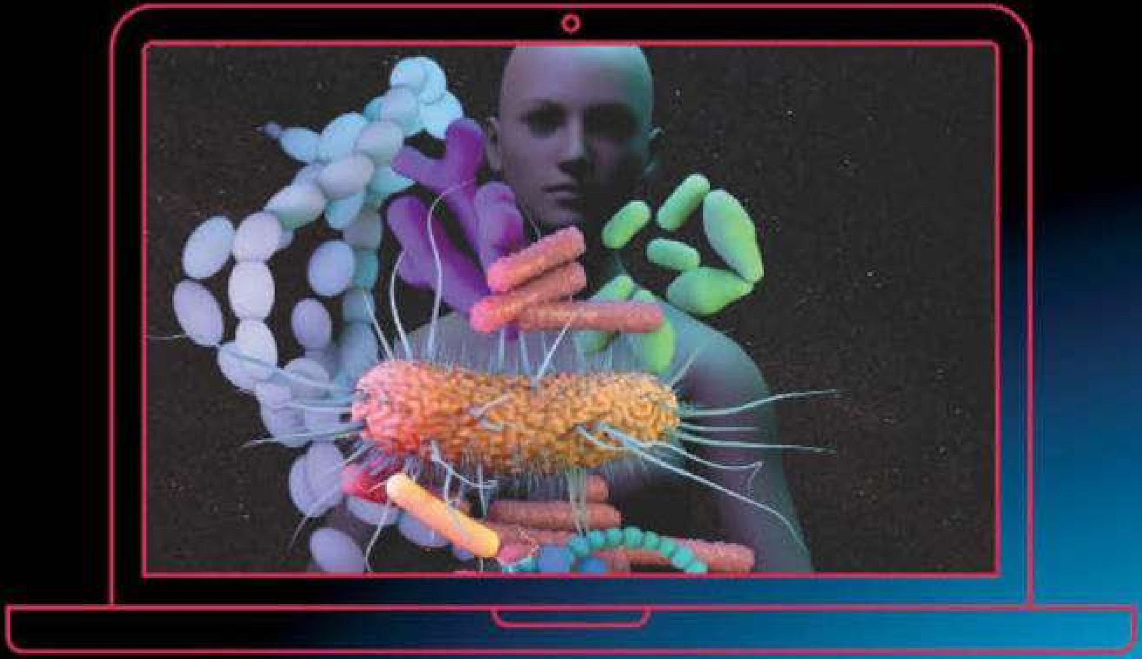

The gut microbiome is more powerful than we’d ever imagined, impacting our feelings and behaviour. Our new course reveals all at newscientist.com/yourmicrobiome

Energy

Nuclear fusion record suggests we really could build artificial suns

Adam Vaughan

A WHITE hot river of heat winds around the bottom of a doughnut-shaped machine before the searing light jumps up to fill the space and vanishes, leaving only darkness. This is the moment when an experiment to reproduce the process powering the sun, called fusion power, set a new global energy record.

The experiment at the Joint European Torus (JET) in Oxford, UK, on 21 December saw a super-hot plasma sustained for 5 seconds, producing a record 59 megajoules of heat energy. JET's previous record was 22 megajoules for less than a second, set in 1997.

"It's not an unexpected result. It is really the pinnacle of the work that is done for years: that yes, it does do what you understood it should do. I feel a certain amount of relief," says team member Volker Naulin at EuroFusion, a consortium of fusion research groups. Nuclear fusion holds the promise of a continuous low-carbon power supply without the radioactive waste problem of nuclear power from fission.

The new record is significant, as it indicates commercial fusion power could become a reality. While 5 seconds might not sound like long, it is the maximum JET's copper magnets can manage. Naulin says the duration and output shows that our understanding of plasma physics is settled. The record suggests a far bigger and more powerful machine being built in France, called ITER, should achieve its goals when it is switched on in 2025.

Those aims are to generate more power than is put in, the long-awaited goal of fusion power, and to do so for a sustained period of time, about 50 minutes initially. Naulin says JET's latest record is a sign that the modelling for ITER is correct. "It's really confirmation that what has been calculated for ITER is not a fantasy number."

The big technology change that enabled the record was a shift away from carbon-based materials in the wall of JET, such as graphite, which act as a sponge for the hydrogen isotopes used to create the plasma. Instead, metals such as tungsten and beryllium were used in the wall, similar to those that will be used for ITER.

"It is really the pinnacle of the work that is done for years. I feel a certain amount of relief"

The fusion attempts were the first at JET in more than two decades to use two types of hydrogen isotope, deuterium and tritium. Most tests in recent years have used only deuterium. Using them both together can achieve fusion at lower temperatures, and is thought by fusion researchers to be the most efficient fuel for a future power station.

Juan Matthews at the University of Manchester, UK, says the scale of the new record means it is "much more significant" than an attempt last August at a US facility using an entirely different approach to creating fusion.

"JET is getting close to break-even, with power close to that being used to run the reactor," he says. "We must remember that JET is using real fuel with tritium as well as deuterium and these pulsed tests will be valuable in making sure ITER is able to get off to a running start once it begins operation. Very few fusion experiments are using tritium." ▮

Animal behaviour

Cricket has strongest known bite of any insect in the world

UNIVERSITY OF BONN IN GERMANY

The raspy cricket is found in the rainforests of north-eastern Australia

THE raspy cricket is the champion of chomp. Found in Australia, it has the strongest bite of around 650 insect species.

"I was initially surprised," says Peter Rühr at the University of Bonn in Germany. "I would have expected that maybe predators are the strongest biters rather than herbivores." It makes more sense when you consider that the raspy cricket (*Chauliogryllacris acaropenates*) bites into living wood to dig out nests, he says.

Before now, researchers had measured bite forces for only around 20 insect species. Rühr and his colleagues have expanded this to include hundreds of crickets, stag beetles, termites, wasps, bees and ants from Australia, China, Europe and Panama collected between 2018 and 2021.

To measure the power of their jaws, the researchers built a tiny metal device containing a crystal that stores electrical energy. They placed the sensor between the tips of each insect's mouthparts, called the mandibles. When an insect bites down, it compresses the crystal, converting the mechanical energy into an electrical current.

Some insects were hesitant to bite, so a threatening paintbrush was used to tickle their abdomen or head to spur a bite. Others, such as stoneflies, refused to bite at all.

The weakest biter was a wasp (*Netelia*) found in Australia, whose maximum bite force was around 1200 times less than that of the raspy cricket (bioRxiv, doi.org/hgkn).

Several stag beetle species (*Prosopocoilus*) ranked near the top. "The stag beetles had a lot of force – one even broke its own mouthparts [during the biting test]," says Rühr. Insects that fight more may have stronger bites, he says.

"It's just the beginning. There are more than a million insect species, many of them are biting and chewing, and we just measured 650," says Rühr. ▮

Carissa Wong

Climate change

The race to capture carbon

Myriad inventive ways of removing greenhouse gases from the air are turning from dreams into reality. **Adam Vaughan** reports

L: CLARE JACKSON/ALAMY; R: CARBON ENGINEERING

Energy firm Drax has a biomass power plant in Yorkshire, UK (left)

Artist's impression of Carbon Engineering's planned direct air capture plant (below)

A CATTLE shed near Edinburgh sucking up methane emissions and a team altering the acidity of seawater in the English Channel might seem unlikely prospects for avoiding increasingly dangerous climate change. But they are just two of 24 projects taking part in a £100 million UK competition for innovative ways of sucking greenhouse gases out of the air.

Governments worldwide have been waking up to the need to develop ways of removing emissions from the atmosphere to meet net-zero targets, which now cover 90 per cent of the global economy. And last year's landmark report from the Intergovernmental Panel on Climate Change was clear: removal strategies work and will be needed to "stabilise" temperature rises this century.

To date, such technologies have largely existed only in virtual simulations. But 2022 looks to be the year that pilot schemes will get off the ground. "They are filling a really useful niche, going from computer models to fields and factories, where we can see how they work in real life," says Steve Smith at the University of Oxford.

The UK is near the forefront of the international race to develop carbon dioxide removal technologies, but is far from alone. The US passed a law that will see $447 million going to research on machines to capture CO_2 from the air. Norway is working on a multibillion-dollar carbon capture and storage project, dubbed Longship, and other Nordic countries are exploring using bioenergy to draw down CO_2.

As well as the UK's £100 million competition, there is a £30 million programme backed by the UK government looking at five ideas, from grinding up rocks to increase their surface area and spreading the dust on farm fields to speed up their natural CO_2 absorption to planting fast-growing grass to absorb carbon. The two dozen schemes hoping to win a share of the competition funding in April are a diverse bunch.

> **"Our children may decide to unwind some of the climate change and go beyond net zero"**

One aims to reduce the pH of seawater so that most of the carbon within it becomes CO_2, which can be captured and stored. The pH is then ramped back up and the carbon-depleted water is pumped back into the sea, where it naturally absorbs more CO_2 from the atmosphere. "We're accelerating the natural processes of the ocean," says Paul Halloran at the University of Exeter, UK, who is working on the project, dubbed SeaCURE.

He says the big attraction is that CO_2 concentrations in seawater are 150 times higher than in the air. This also brings costs down, he says: £300 a tonne of CO_2 removed versus $600 (£442) cited by Climeworks, a Swiss direct air capture firm. Another attraction is that, unlike approaches using trees and crops, it doesn't compete for land.

The idea's weakness is monitoring. Once the carbon-depleted seawater is released back into the ocean, verifying how much carbon it takes up is nigh-on impossible. That might be an issue for firms using the approach to meet their net-zero targets, because they will have to rely on modelled estimates of the carbon saved, rather than hard figures.

Another candidate in the competition is "Green-Shed", led by Carole-Anne Duthie at Scotland's Rural College (SRUC). The idea is to adapt a shed where beef cattle are housed during their final stage of growth, turning it from a fairly open structure into a well-sealed one, then suck out the high levels of methane from it. The power to do this removal comes from an on-site anaerobic digester fed by cattle waste.

Farm power

Like seawater, a cattle shed has higher-than-normal concentrations of greenhouse gases. Another plus is that it can be used with little disruption to farmers. "We're not changing the farming enterprise," says Duthie. Still, how we can store huge quantities of methane economically is an unanswered question, and the scale of the removals remains to be seen.

Such ideas are very much in the early stage innovation camp. "Some of them might work, some of them might not. That's OK at the demo stage," says Emily Cox at Cardiff University, UK. But the

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UK cannot rely on such solutions to remove millions of tonnes of CO_2 and meet current carbon targets, she says.

In the short-term, that role will fall to nature-based approaches, mostly tree planting and peatland restoration, says David Joffe at the Climate Change Committee (CCC), an independent group advising the UK government (see "From food to forestry", right). The reason such measures come first is that they are inexpensive and can take years to draw down carbon.

However, there is only so much land, and so much carbon that trees can absorb, meaning climate targets won't be met without engineered removals in the medium term too. The first big prospect is bioenergy with carbon capture and storage, also known as BECCS, which energy firm Drax wants to deploy in the north of England to burn biomass for power and pipe the CO_2 into old oil and gas reservoirs off the coast. The second is direct air capture (DAC), machines using fans, heat and chemicals to take CO_2 directly out of the air, a technology that Canadian company Carbon Engineering plans to have running at scale in Scotland by 2026.

"They are the main front runners," says Joffe. "Others we regard as, to some extent, speculative. Which is not to say they cannot contribute, but we don't think they're proven enough to include in our scenarios." Keeping alternatives in play is still worthwhile, he says, because there are physical limits to how much biomass can be grown in the UK for BECCS. And DAC is energy intensive, so too much deployment in the next 15 years could consume renewable electricity needed for cars, heat and more.

An Extinction Rebellion protest in London on 1 September 2020

PJRNEWS/ALAMY

The scale of the challenge is huge. By 2050, the UK government thinks engineered technologies will need to remove between 75 and 81 million tonnes of CO_2 a year, up from zero today. Even getting to net zero by 2050 with BECCS, DAC and tree planting is a stretch, says Smith. But they are our best bet, he says. Other ideas aren't worth banking on for 2050, but may prove useful on longer timescales. "Our children may decide we need to unwind some of the climate change we've experienced, and go beyond net zero to net negative. In which case, having started on these technologies will help," he says.

There remain many obstacles. Large-scale storage and transport infrastructure needs to be built, although in the UK and Norway, the governments are already working to enable the pipes and vaults needed. "If we don't make progress on those this decade, there's a bottleneck later on," says Joffe. Old oil and gas reservoirs mean the two countries may end up as big stores for the EU's CO_2, says Ruth Herbert at the Carbon Capture and Storage Association, a UK trade body.

Another issue is that there are still almost no incentives for companies to remove and store CO_2, beyond private-sector initiatives such as firms like Shopify and Stripe paying for DAC removals. That means, for the most part, there is no "route to market" for company boards mulling investment decisions.

From food to forestry

There is a lively debate about how UK farmland will need to change to boost carbon dioxide removal. About a fifth of agricultural land should be turned over to tree planting and other carbon sequestration, says the UK's independent Climate Change Committee, enabled by a shift to more plant-based diets.

Some farmers, such as Andrew Blenkiron in the east of England, are already turning over land used for cereal crops to fast-growing *Paulownia* trees. Pat Brown, the chief executive of plant-based "meat" firm Impossible Foods, is talking to UK farmers about replacing pasture with trees to store carbon. But a shift from food to forestry will be hard.

UK environment secretary George Eustice says farmers are being supported to remove CO_2 through the government's Nature for Climate Fund now and, longer term, through the Landscape Recovery scheme and private green finance. "The key thing really is to expand woodland cover," he says, pointing to the government's target of 30,000 hectares a year. Peatland restoration is also important, Eustice adds, along with technology and innovation. He cites a project in Cornwall capturing methane from livestock and using it instead of red diesel, a fuel used in farm vehicles.

Then there are public attitudes. The 108 people on the UK's first Climate Assembly in 2020, which aimed to weigh the views of the general public, were very cool on engineered removals. "The crucial thing in bringing people along is to have a clear public strategy to say this is what the removals are for: counterbalancing those remaining emissions where we just can't get to zero, not to allow companies off the hook," says Joffe.

90%
Share of global economy with net-zero targets

£100m
Funds for UK CO_2 removal competition

75-81m
Tonnes of CO_2 that the UK needs to remove from the air in 2050

Given all those hurdles, "there is a world in which none of this happens", says Smith. Two possible triggers for failure are hostile public opinion and governments not giving incentives to scale up the innovations that schemes like the competition in the UK are producing, he says. Fortunately, Smith thinks that is unlikely, not least because countries are beginning to realise that avoiding more dangerous climate change means not just CO_2 reductions, but CO_2 removal. "We essentially need to solve this problem in our generation," says Smith. ▮

SHUTTERSTOCK/KRASULA

Zoology

Barn owl's tail could inspire more efficient flying drones

A BARN owl's tail plays a surprising role in flight by making the bird more aerodynamic, which may have implications for drone design.

In aeronautical engineering, anything that provides lift usually also causes drag. This is because a surface that offers lift creates a barrier that requires the flying object to use more energy to keep moving forward through the air, says James Usherwood at the Royal Veterinary College in Hatfield, UK.

For the owl's tail, this seems not to hold. Usherwood and his team filmed a barn owl (*Tyto alba*) gliding through an experimental flight corridor. They used the footage to create a computer model of a barn owl in flight, before isolating the effects of the tail on performance, testing 42 different tail positions.

They found that the owl can use its tail to gain lift and support the bird's weight, while resulting in less overall drag at low gliding speeds.

It probably achieves this by using the tail to affect airflow over the wings, says Usherwood. At an average gliding speed of 28 kilometres per hour, optimal lift and minimal drag occur when the tail feathers are fanned out, and a line following the outer edge of each side of this fan forms an 18-degree angle with the bird's midline, while the tail tilts down 23 degrees from horizontal (*Journal of the Royal Society Interface*, doi.org/hgjj).

Common designs for smaller aircraft often aim to reduce drag by avoiding the use of tails altogether, says Usherwood. These craft, including drones, might experience less drag if they followed the owl's model. **Christa Lesté-Lasserre**

Astronomy

Habitable world may be orbiting dead star

A DISTANT white dwarf is surrounded by space rocks marching in perfect time. This observation offers hints of what may be the first planet detected in the habitable zone of one of these stellar corpses, suggesting that they might be just as good for life as bigger, younger stars.

Jay Farihi at University College London and his team spotted these hints while observing a star called WD 1054-226 about 118 light years away. They found something appeared to be regularly passing in front of the star, causing dips in its light. The biggest dip happened every 23.1 minutes, in a pattern that repeated every 25 hours.

The measurements indicate that the star is surrounded by a ring of 65 comet-sized or moon-sized objects, remarkably evenly spaced in their orbits. "The structures that are transiting are so highly regular that you can't really do that accidentally," says Farihi. That doesn't mean it is aliens, though. "Regular structures in space do invoke this idea of planetary engineering, but I favour the more mundane explanation," he says.

This is that the bits of cosmic debris are kept in order by the gravitational pull of a planet orbiting slightly further away from the star. "If we're correct that there is a planet causing this order, my guess would be that it would be around the size of Mercury or Mars," says Farihi.

The researchers calculated that the orbiting objects are about 2.6 million kilometres from the star, putting their temperatures at around 50°C, which is right in the middle of the range for liquid water. This means that if there is a planet there, it could have the right temperature for oceans and maybe even life (*Monthly Notices of the Royal Astronomical Society*, doi.org/hgjx). **Leah Crane**

Technology

AI beats world's best video game drivers

AN ARTIFICIAL intelligence has beaten four of the world's best human drivers on three different tracks in the racing video game *Gran Turismo Sport*.

Peter Wurman at Sony AI in New York and his colleagues trained the AI, named GT Sophy, using deep reinforcement learning, a type of machine learning that uses rewards and penalties to teach the AI's neural network how to win.

SONY/POLYPHONY DIGITAL

During training, GT Sophy, which was running on a separate computer, played the game on up to 20 PlayStation 4 consoles simultaneously.

By joining forces with a competitive player, the team focused on a small set of the most difficult parts of each track, so that GT Sophy could quickly learn to excel in those areas. The team then challenged four of the world's best *Gran Turismo Sport* players to compete against four copies of GT Sophy in a team race, so eight cars were on the track in all. The AI won 104 to 52, with points calculated according to racers' final positions (*Nature*, doi.org/gpffsf).

The AI's success will, however, have very little impact on other driving technologies, for example improving autonomous vehicles. "It's very much dependent on fine-tuned parameters and features specific to the game," says Georgios Yannakakis at the Institute of Digital Games in Malta. **Carissa Wong**

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Really brief

PARKER ET AL.

Robofish built with human heart cells

Human heart cells that retain the ability to beat have been used to power a synthetic plastic fish. The robot offers an opportunity to probe the biomechanical properties of the heart, and could eventually inform the design of artificial hearts for regenerative medicine (*Science*, doi.org/gpfjrp).

A dinosaur with a very bad cold

An 18-metre-long diplodocid dinosaur that died 150 million years ago was suffering from a respiratory infection at the time of its death. The infection had reached the respiratory air sacs in the dinosaur's neck bones, triggering unusual bony growths (*Scientific Reports*, doi.org/hggs).

Sea level rise threat to African heritage

Rising sea levels this century will more than triple the number of African heritage sites at risk of flooding. By 2050, more than 190 sites could be under threat. They include the remains of Carthage in Tunisia, the capital of the ancient Carthaginian civilisation (*Nature Climate Change*, doi.org/hggt).

Health

Possible Alzheimer's link to sleep is found

THE immune system may remove brain protein plaques associated with Alzheimer's disease on a circadian schedule and this could be affected by sleep loss, suggests a study using mouse cells.

The circadian schedule is an internal clock that controls sleep and a vast array of other bodily processes on a roughly 24-hour cycle. Doctors have long observed that people with Alzheimer's disease have sleep disturbances and circadian disruption, but it remains unclear the extent to which this disruption could be a cause for the condition itself.

Now, Jennifer Hurley at the Rensselaer Polytechnic Institute in New York and her team have found one possible mechanism by which beta-amyloid plaques, which are found in high numbers in the brains of people with Alzheimer's, could be related to sleep. They think the plaques are cleared away by macrophages, immune cells that destroy foreign material, according to the body's daily rhythms.

To investigate this, the team extracted macrophages from mice bone marrow and fed them beta-amyloid plaques at different times of day. By counting the plaques the cells had consumed, the researchers could map out the circadian rhythms of the macrophages.

Hurley and her team also identified a class of circadian-controlled proteins involved, called heparan sulphates, which Hurley thinks may signal to the macrophages when to clear away the plaques (*PLoS Genetics*, doi.org/hgkd). **Alex Wilkins**

Diet

SHUTTERSTOCK/RAWPIXEL.COM

Here's how you need to eat in order to live 10 years longer

PERMANENTLY adopting a healthier diet in place of typical Western fare may extend life by a decade or more on average for people under 60.

"The estimated life extension is mainly due to a reduction in the risk of heart disease, diabetes and cancer," says Lars Fadnes at the University of Bergen in Norway.

His team started with recent meta-analyses of the effect of eating various amounts of particular food types, such as fruits. These findings were combined with data on global mortality and what people currently eat to estimate the impact of a permanent change in diet.

The highest estimates of lifespan extension are based on a diet designed to maximise the health benefits. This involves having no red or processed meat, no sugar-sweetened beverages, less dairy and eggs, and eating more legumes, whole grains and nuts.

For younger adults, the benefits would be greatest. A 20-year-old man who moved to the optimised diet would live 13 years longer on average. For a woman, the equivalent figure is 11 years (*PLoS Medicine*, doi.org/hgjp).

Eighty-year-olds of either sex would reap the smallest benefits, living about three years longer. **Michael Le Page**

Materials

Coal ash could supply vital metals for tech

RARE earth elements that are crucial to smartphones and electric vehicles can now be extracted from coal waste.

Neodymium, europium, terbium and other rare earth metals that were once barely heard of are now commonplace in phone touchscreens, electric vehicle motors, wind turbines and other modern technologies. Mining them is inefficient and costly, as large areas of land must be dug up to get small amounts.

James Tour at Rice University in Houston, Texas, and his colleagues have come up with a way to recycle these metals from fly ash, a fine black powder that is left over when coal is burned in power plants.

They developed a technique that involves packing the ash into a quartz tube and running a large electrical current through it for 1 second to heat it to 3000°C. This breaks open microscopic glass spheres in the ash that contain rare earth metals. It also converts the metals from phosphate to oxide forms that are easier to separate out (*Science Advances*, DOI: 10.1126/sciadv.abm3132).

Each tonne of fly ash contains only about half a kilogram of rare earth elements, but there is a lot of ash to exploit. **Alice Klein**

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Comment

Trouble in the metaverse

Throughout history, there has been backlash to technological progress – so why should now be any different, asks **James Ball**

MICHELLE D'URBANO

HARDLY a day goes by without some new claim promising to bring us closer to the metaverse in the not-too-distant future. Meta (the company formerly known as Facebook) and Microsoft are both enthusiastically pushing virtual reality worlds and staking the future of their multibillion-dollar businesses on our receptiveness to the idea. Vodafone is predicting that smart devices could monitor our health and even our brains by 2030. And Elon Musk has claimed his Neuralink technology may be able to help people with paralysis walk and enable everyone to upload their memories to the cloud within the decade.

On hearing about this, some of us will feel sheer excitement – but others will feel unsure, uneasy or downright opposed. Our habit in recent history has been to shun or scorn those with misgivings on technological progress. It may be time to re-examine that.

There has been a backlash to technology since historical records began. Every new form of communication – from telegram to telephone and beyond – has attracted criticism for increasing the pace of life. Novels were condemned for ruining attention spans, and people once feared that cars travelling at 20 to 30 miles per hour might deprive their passengers of oxygen, perhaps fatally.

With the benefit of hindsight, contemporary resistance to technological advancement can look like utter folly – but often it isn't. The Luddites, for example – the smashers of mill machinery in the early industrial revolution – are generally referred to as a historical punchline. But if we look at their real grievances, it wasn't some naive anti-progress movement; it was about economics. Cotton mills replaced skilled, home-based, independent work with lower-skilled or even unskilled work, in unsafe conditions in a factory, accompanied by much less autonomy and much less pay.

The mill might have been more efficient and thus more profitable, but it would take decades of campaigning to distribute those gains even approximately fairly – with the birth of the trade union movement, health and safety laws, the welfare state and more. Seen through that prism, was resistance really so irrational?

When we look at the latest hype cycle, while cryptocurrency and metaverse advocates would like to paint sceptics as simply rooted in the past, at least some doubts are well founded.

The reasons to be wary of the next wave of technology are manifold. One is simply whether the technologies in question are where they are claimed to be. Musk, in particular, has a habit of overpromising, whether on travel to Mars, ultra-high-speed trains or self-driving cars. Few in the know take his claims for Neuralink seriously.

Other more imminent metaverse technologies rely on virtual reality, which still largely consists of clunky headsets and odd arm controls – all just to be able to manoeuvre an avatar through an awkward online world. VR has been "the next big thing" for decades and the public has consistently felt otherwise: there isn't much to do once you are there, the technology gives many people motion sickness and, perhaps most problematically of all, the whole thing just seems irredeemably naff.

Beyond a relatively small group of enthusiasts, health tracking hasn't caught the wider public by storm, not least because many consumers worry about what will happen to their data. More broadly, while some of us love the idea of uploading our minds one day, others feel an innate horror at blurring such lines.

There is much to anticipate as we bring online and offline worlds together. But we should learn not to dismiss concerns or wariness about this, either. There are many rational reasons for people to take part in the techlash. ▮

James Ball is the global editor of The Bureau of Investigative Journalism

Field notes from space-time

Do look down We shouldn't only celebrate spacecraft staring out at the universe, but also those turned on Earth, helping us live better on our own planet, says **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading
Jessica Hernandez's Fresh Banana Leaves: Healing Indigenous landscapes through Indigenous science *is an important intervention.*

What I'm watching
We are pretty into The Gilded Age *right now.*

What I'm working on
I just wrapped up edits on the paperback edition of my book The Disordered Cosmos.

This column appears monthly. Up next week: Graham Lawton

WHEN we think about space launches, we tend to picture telescopes and astronauts. We don't tend to think about farming. Yet on 1 March, a satellite is due to lift off from Cape Canaveral in Florida, and one of its main contributions will be to help farmers work their land more efficiently.

The Geostationary Operational Environmental Satellite-T (GOES-T, aka "ghost"), operated by the US National Oceanic and Atmospheric Administration (NOAA), is the latest in a long line of probes designed not to look out to deep space, but back at Earth. In this case, it is designed to better understand how our atmosphere works and how its activity is shifting due to climate change.

Farmers will use the data returned, for example, to figure out precisely how much water their crops need. The new satellite will offer detailed information about a phenomenon called evapotranspiration, the process through which water evaporates from soil and plants and enters the atmosphere. Seeing how much evapotranspiration is occurring on their land and comparing this with the amount of water they gave their crops, farmers can calculate how much water those plants used. The result is that farmers can reduce water waste.

Of course, farmers aren't the only ones interested in the weather. These days, we are all getting used to increasingly extreme weather events. Here in New Hampshire, we don't get snow when we used to, and when we do get it, it isn't nearly as much as in decades past. Oddly, the folks south of us, where it is typically warmer, are getting our snow. Climate change is so dramatic that we are all witnessing it in real time, and I find what I'm seeing stressful. Of course, our own individual observations are largely anecdotal. Our systematic understanding of climate change is coming from Indigenous people, who know their local ecosystems best, and from scientific researchers who study our global ecosystems.

Necessarily, this kind of research not only uses ground-based observations, but also snapshots of the big picture from space. GOES-T is ultimately a next-generation weather satellite that will orbit Earth at the same speed that our planet rotates on its axis, allowing it to remain stationary relative to the surface and continuously observe the Western hemisphere. It is the latest in the GOES-R series of satellites, which creatively is comprised of GOES-R, GOES-S, GOES-T, GOES-U. When it comes to monitoring conditions on Earth, all four satellites are specifically equipped with the capacity to take images in the visible and infrared. This allows NOAA, with the support of NASA, to track major events such as hurricanes, tornadoes, floods, fires and volcanic eruptions like the one that recently caused a disastrous tsunami in Tonga.

> **"We can track major events, such as hurricanes, tornadoes, floods, fires and volcanic eruptions"**

But Earth's weather isn't the only weather GOES-T will be tracking. All satellites in the GOES-R series are also able to take images of the sun and monitor space weather, which is what we call the collection of phenomena that impact conditions in our solar system.

For example, the sun has powerful magnetic fields that can, ultimately, affect technology here on Earth. Solar flares associated with these fields, and mass ejections that are often associated with them, can be seriously disruptive, damaging power supplies, GPS and radio communications. They are also a risk to space facilities such as the International Space Station.

Earlier this month, the orbits of around 40 Starlink satellites, which provide internet access, failed because of the impact of space weather on the atmosphere. The sun also spits out high-energy particles known as the solar wind, which, when they interact with Earth's magnetic field, produce beautiful night sky colours. These dancing glows are the auroras that can be seen near the poles.

GOES-T's specialised instruments help us track all these phenomena. Here at the University of New Hampshire, my colleague James Connell, a professor in the department of physics and in our world-class Space Science Center, is heavily involved in the development of the GOES-T Energetic Heavy Ion Sensor. This will measure heavy ions flung out by the sun that fly through Earth's magnetic field and will contribute to getting a global picture of the energetic particle climate that envelops our world and affects both our spacecraft and life on the ground.

This sort of work doesn't tend to get much attention, and yet it is important because it is only by developing these instruments that we can gather the information we need. The painstaking work behind these kinds of craft, as much as the headline-grabbing launches of the rockets that carry the satellites, is critical to living well here on Earth. ■

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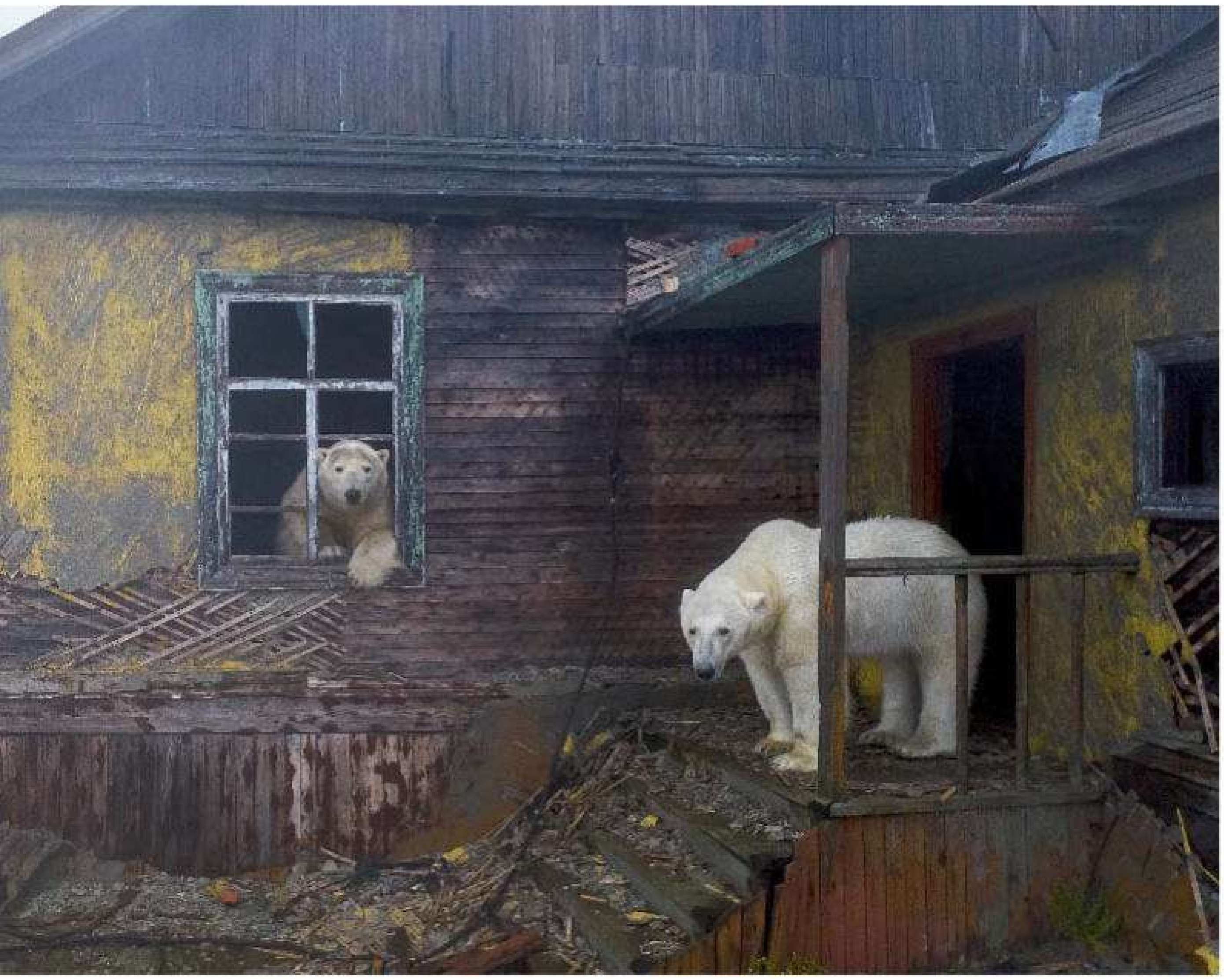

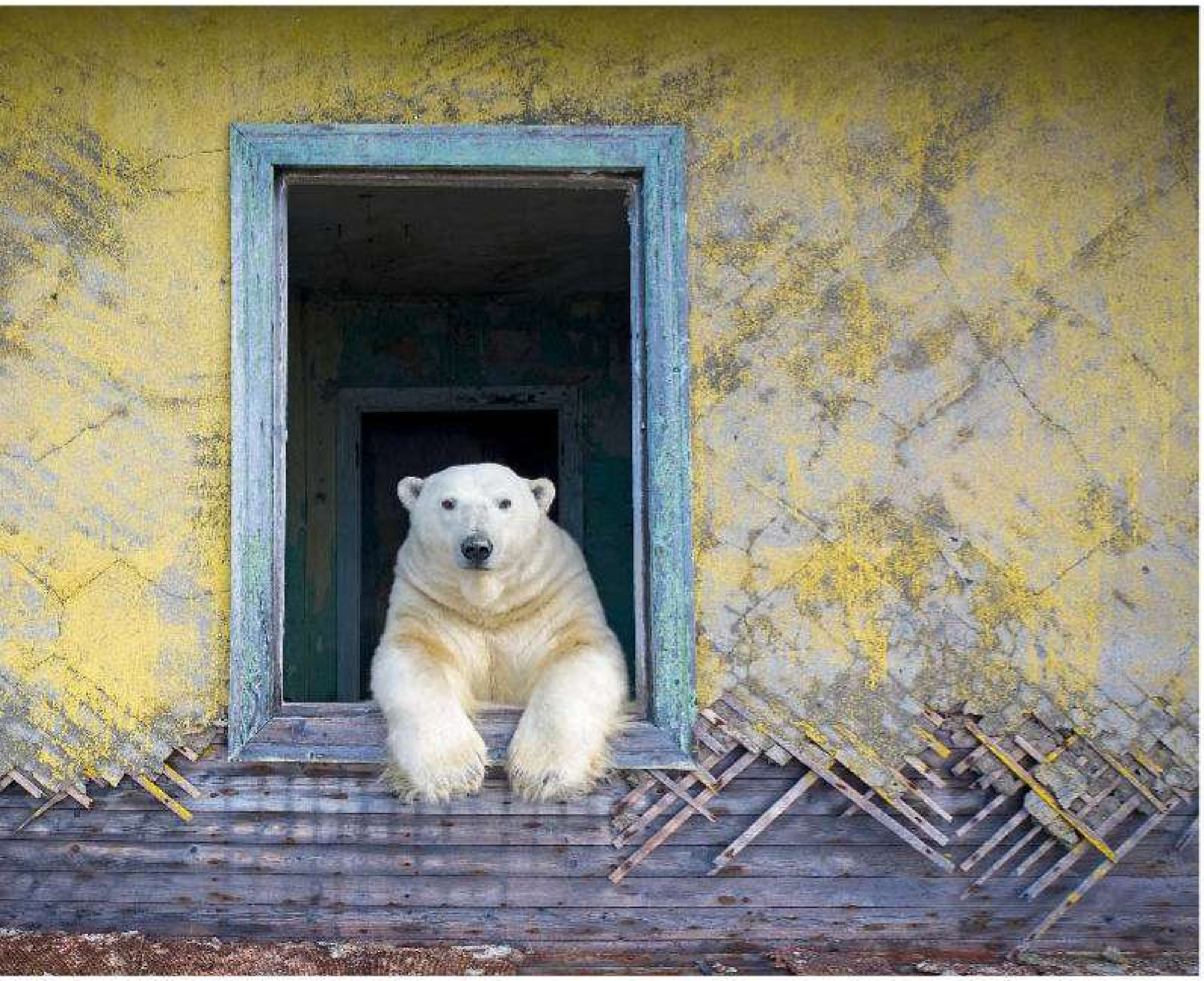

Bearbnb

Photographer Dmitry Kokh

AN ABANDONED weather station and its surrounding settlement is an unconventional place to find polar bears, but then we are living in unconventional times.

Wildlife photographer Dmitry Kokh happened upon the animals when the boat he was on took shelter from a storm at the Russian island of Kolyuchin in September 2021. It was too dangerous to walk on the island, so he took pictures of the station's unusual residents using a camera drone fitted with low-noise propellers, so as not to disturb the bears too much.

According to Kokh, there were about 20 individuals in sight, most of them male. Kolyuchin, off the coast of eastern Russia in the Chukchi Sea, hasn't been inhabited by people for decades. It is also surrounded by sea ice – polar bears' primary habitat – for most of the year, giving the bears easy access to the island in time for summer, when sea ice wanes.

Whatever environmental conditions or opportunities for hunting led the animals to Kolyuchin, they certainly seemed to be making the most of their home comforts.

Gege Li

Editor's pick

Observations on the new quantum perspective

5 February, p 38

From Paul Seedhouse, Newcastle, UK

Your article gives an account of the "Wigner's friend" thought experiment, an adaptation of the one involving Schrödinger's famous cat. Wigner's friend opens the cat's box – which contains a radioactive particle, the random decay of which releases a deadly poison – to establish the animal's state, but Wigner himself is outside the lab door. The perspectives of the two friends regarding the cat's state are said to be mutually exclusive and the author's conclusion is that this "is a deep paradox that seems to reveal a splintered reality".

I disagree. The cat, Wigner and his friend are entangled in the same reality and perspective because of the possibility that, at the precise moment Wigner's friend opens the box, the particle decays, thus releasing the poison. This could kill not only the cat, but also Wigner's friend and even Wigner, if the poison is virulent enough. Wigner's experiment assumes the cat's state can only be determined visually, but transmission of information via entropy through the air is possible in this case, resolving any paradox.

From Andrew Mills, Southampton, UK

The article echoes ideas that I deduce from our current sphere of knowledge and speculation on quantum observation and our connection to it. We are far more connected to the machinations of the universe than our apparent view and understanding of reality, or classical physics.

I fear for future of fertility in our polluted world

29 January, p 44

From Geoff Harding, Sydney, Australia

Evidence is accumulating that our accelerating poisoning of the environment has insidiously affected the health of humans and animals, with increasing impact, for decades. Of great concern are recent claims that a wide range of "endocrine-disrupting chemicals", often referred to as "everywhere chemicals" due to their ubiquity, are responsible for a serious decline in sperm counts in people and animals.

If this trend continues, sperm counts may be too low for fertility. One can imagine consequences. For example, in the future, women who want a child may insist on a sperm count to determine the suitability of a prospective partner.

Try this spot as birthplace of our new geological era

29 January, p 14

From Martin Murray, Telford, Shropshire, UK

I would like to nominate a local place – Ironbridge – as ground zero for the Anthropocene epoch. It is a World Heritage Site because it was the birthplace of the industrial revolution. So much foundry slag was produced that it was crushed and used as roadstone. This artificial rock can still be found in the base layer of many local roads. This, plus the fact that Ironbridge's landscape and geology have been reworked beyond recognition, should make it a contender.

From Peter Sutton, Guildford, Surrey, UK

I am struggling to answer one question about the Anthropocene: which is more stupid, bringing about the devastation of Earth or naming this event after ourselves?

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

There have been suggestions that the new Anthropocene epoch, marking a signature of human influence on our planet's geology, should start with the industrial revolution in 1750 (for similar reasons to those your reporter Adam Vaughan covers, albeit earlier than the 1950 he mentions), and that for the past quarter of millennium, we have been living in this new epoch's first age. This age would also need a name. There are proposals to call it the Capitalinian, for obvious reasons.

There is a good way to save energy – greener software

Letters, 29 January

From Steve Dalton, Chipstead, Kent, UK

David Thorpe cites the Jevons paradox, which highlights the difficulty of turning energy efficiency into energy savings, as wrongly "relying on logic alone". One area where logic can be applied to achieve real energy savings is software programming.

A previous generation of programmers had efficiency constantly in mind, as computers were slow. Today, the emphasis is on getting code written quickly and throwing power at it if it needs to go faster. It might be hard to change the culture and economics of software development, but as we increasingly rely on software, we need to make it much greener.

Quantum edifice may be a sign of vast simulation

29 January, p 48

From Alec Williams, Whitehead, County Antrim, UK

In your interview, David Chalmers says we could perhaps be living in a *Matrix*-style simulation operated by an outside agency. If we are, then it is almost certainly digital. Even the most advanced operators would be unlikely to be able to use infinite bandwidth. Therefore, zooming in sufficiently, the simulation should pixelate.

What do we find when we zoom in within our universe? Everything is quantised. Could the edifice of quantum mechanics be describing the limits of a digital simulation?

Migraine was wiped out by medical emergency

29 January, p 38

From Jan Horton, West Launceston, Tasmania, Australia

My first experience of migraine more than 50 years ago was immediately after starting an oral contraceptive. Once triggered, I was stuck with a monthly dose of pethidine, a painkiller that wiped me out for a week each time. Then a miracle occurred. I had emergency surgery, with a hysterectomy, appendectomy and removal of "lots of bits and pieces you can do without", in the words of the surgeon. I have had no more migraines in the 40 years since.

Happiness: there may be a better way

22 January, p 38

From John Moore, Nelson, New Zealand

Perhaps contentment should trump happiness. The concept of happiness as a pursuit tends to suggest a relentless chase, perhaps for new experiences. Happiness itself is a transient and ephemeral emotion. In contrast, contentment is pervasive and readily understood. You do mention satisfaction in your article, but contentment is richer than that and suggests a degree of harmony with the natural world. ▮

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For the record

▮ **Our look at sites that could mark the beginning of the Anthropocene epoch (29 January, p 14) should have used an image of Crawford Lake in Milton, Ontario, Canada**

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Sharing the seas

The question of who owns the oceans and who gets to enjoy their spoils has more than a whiff of colonialism about it, finds **Simon Ings**

Book

A Blue New Deal: Why we need a new politics for the ocean

Chris Armstrong

Yale University Press (22 February)

THE oceans regulate the climate, provide us with food and produce at least half the world's oxygen. And how do we repay them? By overharvesting their limited resources and polluting them with oil, plastics and noise.

Chris Armstrong, a political theorist at the University of Southampton, UK, says that if we are to save the seas, something has to change. In *A Blue New Deal*, he argues that the institutions and laws that govern our oceans are too fragmented, too weak and too amenable to vested interests to protect the marine environment from further destruction. They are also failing to address the inequalities that exist between rich and poor nations, he says.

He makes his case for a new approach by exploring the mess we are in. Historically, ocean governance has been shaped by two contrary ideas: the freedom of the high seas, espoused in 1609 by Dutch philosopher Hugo Grotius in his book *The Free Sea*; and the more familiar idea of enclosure, by which a coastal state is entitled to exclusive control and enjoyment of its immediate marine environment.

Grotius's vision of an oceanic free-for-all would allow anyone with the wherewithal to exploit an ocean resource to do so as much and as often as they desire. This was a not entirely unreasonable position in the 17th century, given the limited technology available at the time.

Clearly, though, it is no longer workable given that only a handful of rich nations can afford the expensive technologies required for seabed mining and mineral extraction.

The arguments against enclosure are perhaps best explained by reference to a 1968 article by ecologist Garrett Hardin, in which he said that "Freedom in a commons brings ruin to all", usually expressed as the "tragedy of the commons".

The problem in applying this to the sea, as Armstrong points out, is that it isn't necessarily true. The historical record is full of examples of resources held in common and governed equitably for hundreds of years. In his view, "the real tragedy for individual 'commoners' was enclosure itself, which saw them being evicted from the land by wealthy landowners".

> "Only a handful of rich nations can afford the expensive technologies required for seabed mining and extraction"

Armstrong laments that the same issue plagues the enclosure of the seas, with rich nations enjoying the status of wealthy overlords. This, he blames on the 1994 UN Convention on the Law of the Sea, which established exclusive economic zones (EEZs) extending for up to 200 nautical miles from nearly every shore.

The rules exclude landlocked nations, including nine of the world's 12 poorest countries, from a share of the spoils. But they don't prevent richer nations from licensing the rights to exploit the EEZs of countries too poor to do so themselves.

And, while the law gave every state-owned atoll, rock and island an exclusive patch of sea to exploit, many belong to former colonial powers and other powerful nations. As a result, the US, the UK, France, Russia and Australia now command the resources of more than 45 million square kilometres of ocean.

What can be done? Perhaps a version of the treaty that, in 1961, established Antarctica as a place of peace and international cooperation – a commons in other words. Shortly after, the UN Outer Space Treaty of 1967 did the same for the worlds beyond our own. It isn't beyond our legal capacities, Armstrong reasons, to govern our oceans along principles of common management, benefit sharing and even technology transfer between rich and poor nations.

Where Armstrong comes unstuck is in his ideas for enforcement. It is all very well to dream up a "World Ocean Authority" whose deliberations no state would have the power to veto or depart from. But what omnipotent and omniscient power will set up and drive all this selfless sharing? Not, I would bet, the destitute seafarers of the Gulf of Thailand; nor the blue whales and other non-human stakeholders of our increasingly stressed oceans. ▮

Simon Ings is a writer based in London

STUART CONWAY/GETTY IMAGES

Who has the right to drill the seabed for oil, gas or other valuable resources?

Bad moon rising

Finally, a disaster movie without a message and that is fun to watch, says **Leah Crane**

Film
Moonfall
Roland Emmerich
In UK cinemas now

CENTROPOLIS/R.BAJO

Disgraced astronaut Brian Harper (Patrick Wilson) is just the man to tackle the moon's real dark side

ALL I wanted was to not be bludgeoned over the head with subtext. If I had to sit through one more not-so-subtle reframing of climate change or the pandemic as a different kind of disaster, I think I would scream. My neighbours can thank Roland Emmerich, then, for the relative peace while I watched *Moonfall*, give or take the bombastic sci-fi sound effects and occasional bursts of laughter.

Moonfall is vintage Emmerich, with notes of his 1996 film *Independence Day*, themes reminiscent of the 2014 film *Interstellar* and a few scenes that are very *Star Wars*. The famous *Star Wars* line "that's no moon" would fit in perfectly. Throughout, *Moonfall* is littered with references to science fiction, both recent and classic.

John Bradley (*Game of Thrones*) has a star turn as K. C. Houseman, a conspiracy theorist-turned-hero who spots before anyone else that the moon seems to be falling to Earth. Halle Berry and Patrick Wilson are also compelling as a NASA executive and a disgraced former astronaut, respectively. Donald Sutherland is fascinating and a little haunting as the keeper of NASA's darkest secrets. If all these roles sound familiar, it is because this is classic sci-fi: every character is archetypal, and every sci-fi buzzword is present and accounted for.

That isn't to say the film is predictable, and it certainly isn't boring. It starts slow, but when it gets going it is packed with action, incredible special effects, spooky tentacles emerging from a lunar crater and the catchy line: "Save the moon, save Earth." Somehow, despite the camp subject matter, the film succeeds in taking itself fairly seriously.

The science in *Moonfall* is largely plausible, although it is, of course, exaggerated for effect. It must be said, because this is a science publication, that the moon is in fact slowly receding from Earth and it would be nigh-on impossible to drag it closer. If it were coming closer at the rate portrayed in the film, Earth would almost certainly be destroyed – and most of what our heroes in the film attempt to do would be impossible for practical and geopolitical reasons. And after the events of the movie, the planet would be uninhabitable.

> "In real life, scientists are extraordinarily bad at keeping quiet about new and exciting discoveries"

There are a few other irritations for those of us who follow real science. Some characters in the film make arguments for space-related conspiracy theories that may at first glance seem almost convincing. But in real life, scientists are extraordinarily bad at keeping quiet about new and exciting discoveries. NASA is portrayed in an inexplicably negative light, while Elon Musk and his companies are mentioned with eye-rolling regularity to the point that it starts to feel like product placement.

But none of that matters when you are watching the moon rise over the horizon, so close to Earth that it is mowing down skyscrapers and dragging the sea into the sky. Thinking about plausibility feels like a waste of time when you could, instead, think about how the filmmakers animated some of the more impressive scenes.

Overall, *Moonfall* is good old-fashioned fun, an apocalypse movie that didn't feel the need to remind us that we are living through apocalyptic times. If you have enjoyed any of the major space films of the past few decades and any of the *Fast and the Furious* movies, you will like it. The premise is pleasingly outlandish while mostly remaining believable, as is the plot. It has moments of humour, stretches of gripping action, gorgeous views and plenty of heart. I highly recommend it. ▮

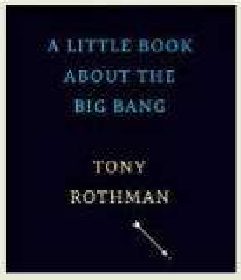
Don't miss

Visit

A New Nature at White Cube Bermondsey in London spotlights the work of the late Isamu Noguchi, whose sculptures in galvanised steel and other industrial materials explore the fundamental structures of nature.

Watch

From is a new sci-fi horror show made by the executive producers of *Lost*. It sees unfortunate travellers trapped in a small town in Middle America, terrorised by strange creatures that only come out at night. The series streams on Epix from 20 February.



A LITTLE BOOK
ABOUT THE
BIG BANG

TONY
ROTHMAN

Read

A Little Book About the Big Bang by Tony Rothman, a former editor at *Scientific American*, explores arguably the most evidenced – and at the same time most mysterious – idea in modern cosmology.

DAN BRADICA; CHRIS REARDON/EPIX ENTERTAINMENT

The film column

From Russia with flu A surreal and sometimes exhausting journey through one man's delirium provides an ambitious and mischievous take on history, aliens and the human mind, finds **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

SERGEY PONOMAREV/SOVEREIGN FILMS

***Petrov's Flu* is an ode to Russian sci-fi and absurdist art**

Film
Petrov's Flu
Kirill Serebrennikov
In UK cinemas now

PETROV (Semyon Serzin) is riding a trolleybus home across the snowbound city of Yekaterinburg when a fellow passenger mutters that the rich deserve to be shot. Seconds later, the bus stops, Petrov is pulled onto the street and a rifle is pressed into his hands. Street executions follow. Then, he is back on the bus and it is unclear how much of that actually happened.

Petrov's Flu is an ambitious, mischievous film, one that is rich in allusions to Russian history, literature and cinema. It is also a painfully precise, gut-wrenching depiction of what it is like to run a high fever. Seeing everything from Petrov's sick, disjointed point of view, we find the real world sliding away again and again, often into violent absurdity.

Petrov's fever gradually breaks over the course of the film, but it is a while before we can be confident about what is real and what isn't: whether his friend, the drunken mischief-maker Igor (Yuri Kolokolnikov), is real and whether Sergey (Ivan Dorn), the struggling writer who browbeats poor Petrov on every point, is a figment of Petrov's febrile imagination.

At the start, *Petrov's Flu* is very much a sci-fi movie. The city is languishing under an epidemic that arrived accompanied by lights in the sky; Petrova (Chulpan Khamatova), Petrov's estranged wife, is possessed by a demonic alien force during a library poetry reading; UFO-themed street graffiti comes to life and wiggles across the screen.

> **"Petrov's fever gradually breaks, but it is a while before we can be confident about what is real and what isn't"**

As reality and hallucination part company, however, it becomes something different: a film about parents and children; about creative work, pretension and ambition; and also, strongly, about Russia's love of science fiction.

At its birth, Western science fiction, and especially US science fiction, celebrated adventure and exploration. Russian sci-fi has always been more about finding and building homes in a hostile environment. It is also strongly religious in spirit, and was indeed for many years one of Russia's very few outlets for spiritual expression.

The aliens in Russian science fiction invariably offer some form of redemption to a struggling humanity, and *Petrov's Flu* is no exception. One of the most affecting scenes in the film is when Petrov, overcome with fear, dashes with his son to a local hospital, only for the pair to be intercepted by a kindly UFO.

Such are Petrov's fever dreams, coloured by his space-loving childhood and his adult career drawing comic books. At one point, he remembers his mum and dad decorating a Christmas tree with festive plastic astronauts; at another, Petrova goes on a murderous rampage among the climbing-frame rockets and spaceships of a dilapidated playground.

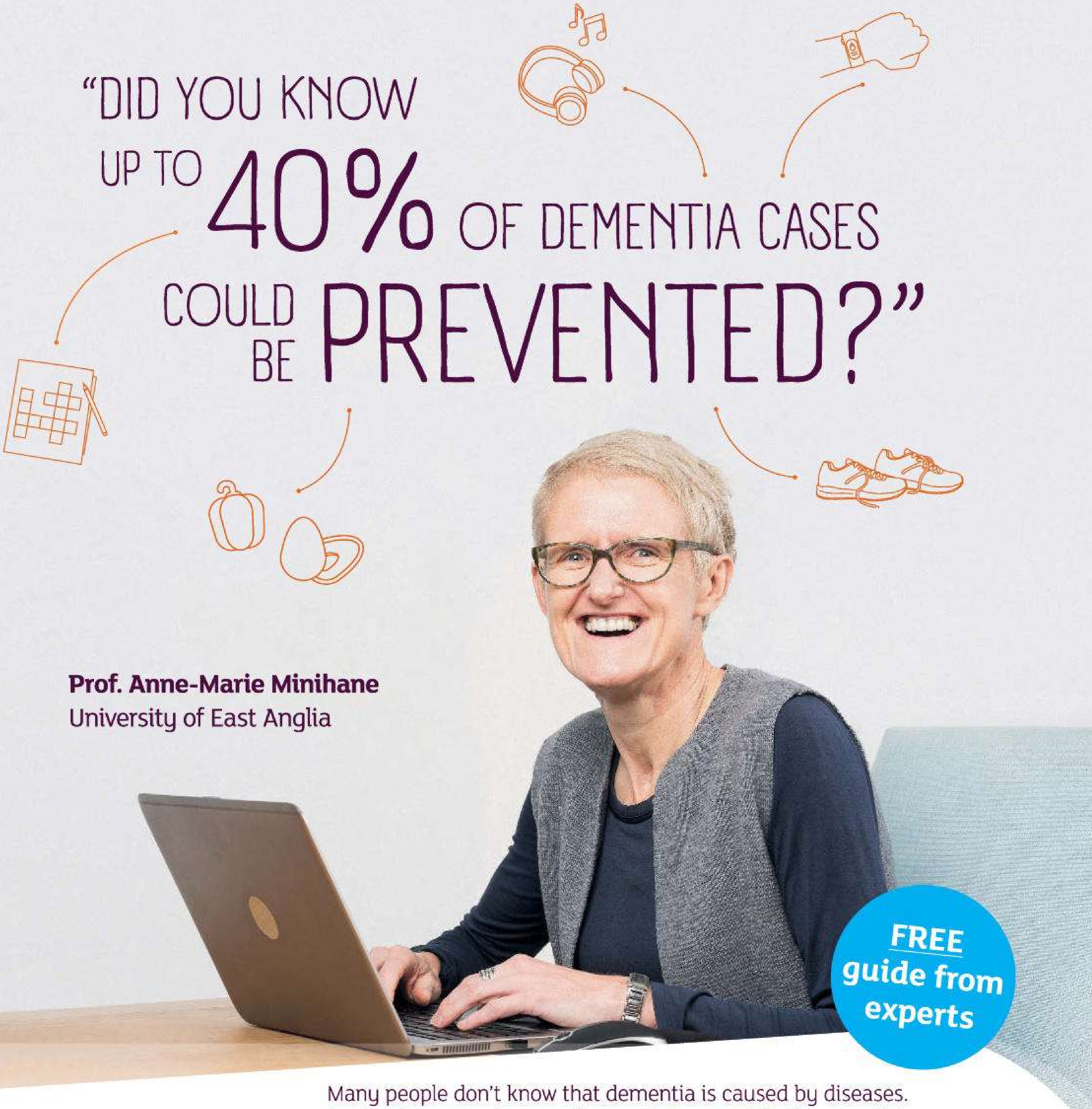
Fans of Andrei Tarkovsky, director of 1970s science-fiction classics *Solaris* and *Stalker*, will enjoy the nods to key moments in those films. But it would be a mistake, I think, to watch this film for the sci-fi in-jokes. True, *Petrov's Flu* is a shocking and funny contribution to Russia's centuries-old tradition of absurdist art. But it is also a film about people, not to mention an extraordinary evocation of febrile delirium and its assault on the mind.

In the end, as fantasy and reality separate, what might have seemed to be a disconnected bag of bits (some tender, some shocking, all horribly entertaining) turns out to be a puzzle that, once complete, leaves us exhausted but satisfied. ▮

Simon also recommends...

Book
Omon Ra
Victor Pelevin
Faber and Faber
Siberia is nicer than outer space – but not by much. The Soviet bid to land warm bodies on the moon inspired this savage, surreal satire.

Film
The Zero Theorem
Terry Gilliam
Set in an hallucinatory, "metaversal" future, this film stars Christoph Waltz as a computer scientist hired to prove that humanity's work amounts to nothing.



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Prof. Anne-Marie Minihane
University of East Anglia

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Making a mind

In the push to make artificial intelligence that thinks like humans, many researchers are focused on fresh insights from neuroscience. Should they be looking to psychology instead, asks **Edd Gent**

ARTIFICIAL intelligence has come a long way. In recent years, smart machines inspired by the human brain have demonstrated superhuman abilities in games like chess and Go, proved uncannily adept at mimicking some of our language skills and mastered protein folding, a task too fiendishly difficult even for us.

But with various other aspects of what we might reasonably call human intelligence – reasoning, understanding causality, applying knowledge flexibly, to name a few – AIs still struggle. They are also woefully inefficient learners, requiring reams of data where humans need only a few examples.

Some researchers think all we need to bridge the chasm is ever larger AIs, while others want to turn back to nature's blueprint. One path is to double down on efforts to copy the brain, better replicating the intricacies of real brain cells and the ways their activity is choreographed. But the brain is the most complex object in the known universe and it is far from clear how much of its complexity we need to replicate to reproduce its capabilities.

That's why some believe more abstract ideas about how intelligence works can provide shortcuts. Their claim is that to really accelerate the progress of AI towards something that we can justifiably say thinks like a human, we need to emulate not the brain – but the mind.

"In some sense, they're just different ways of looking at the same thing, but sometimes it's profitable to do that," says Gary Marcus at New York University and start-up Robust AI. "You don't want a replica, what you want is to learn the principles that allow the brain to be as effective as it is."

Whether the mind and the brain can even be thought of as separate is controversial, and neither philosophers nor scientists can pinpoint where one might draw the line. But exactly what point on that spectrum AI researchers should be focused on for inspiration is currently a big debate in the field.

There can be no doubt that the brain has been a handy crib sheet. The artificial neural networks powering today's leading AIs, such as the impressive language model GPT-3, consist of highly interconnected webs of simple computational units analogous to biological neurons. Like the brain, the behaviour of the network is governed by the strength of its connections, which are adjusted as the AI learns from experience.

> **"AIs can struggle to apply their skills outside highly specific niches"**

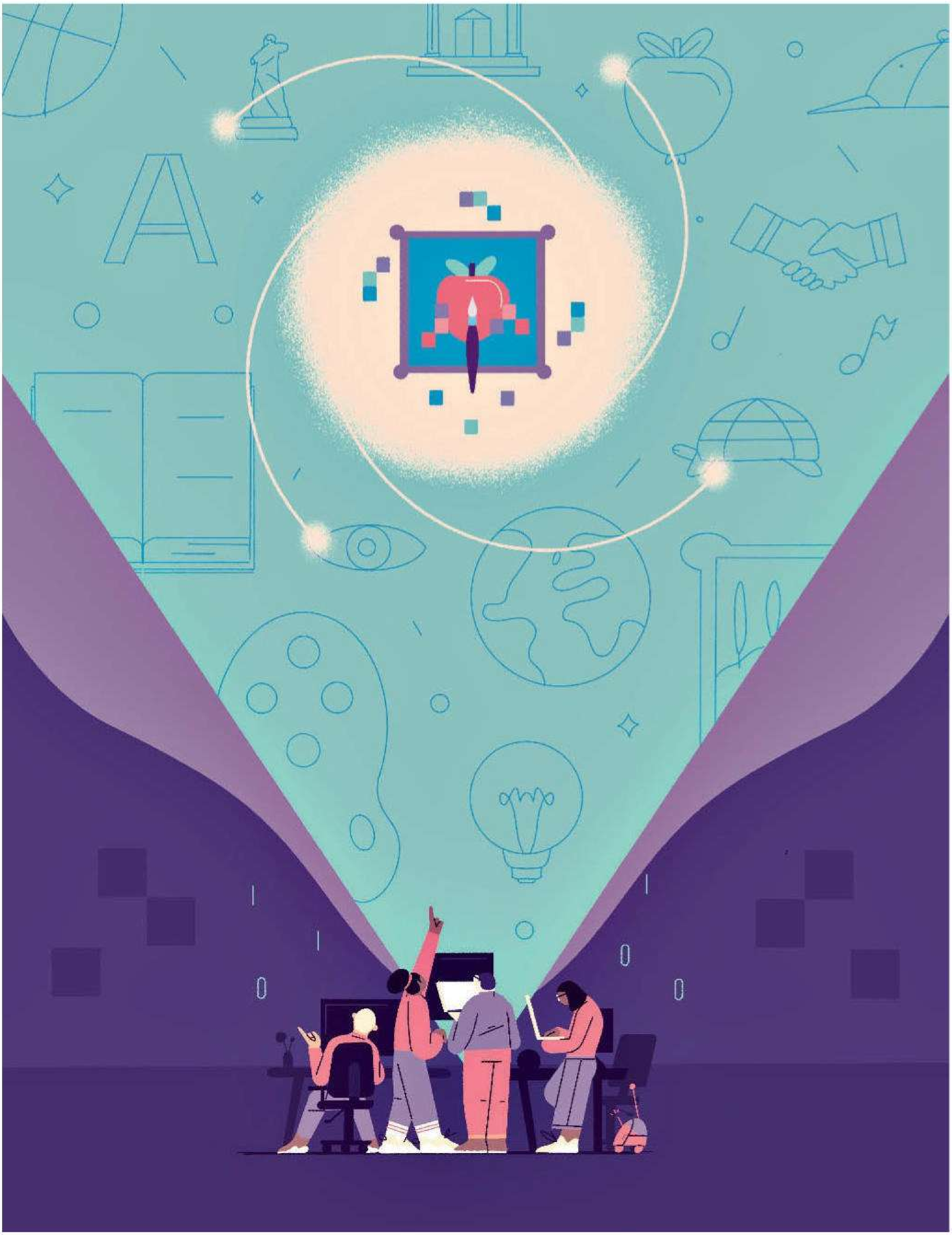
This simple principle has proved incredibly powerful and today's AIs can learn to spot cancer in X-rays, navigate flying drones or produce compelling prose. But they require mountains of data and most struggle to apply their skills outside highly specific niches. They lack the flexible intelligence that allows humans to learn from a single example, adapt experiences to new contexts or use common sense to reason about unfamiliar situations.

One reason might be that the similarities between real brains and AIs are only skin deep. One disparity that has recently come to the fore is in the processing power of artificial neurons. The "point neurons" used in artificial neural networks are a shadow of their biological counterparts, doing little more than totting up inputs to work out what their output should be. "It's a vast simplification," says Yiota Poirazi, a computational neuroscientist at the Institute of Molecular Biology and Biotechnology in Greece. "In the brain, an individual neuron is much more complicated."

There is evidence that neurons in the cortex – the brain region associated with high-level cognitive functions like decision-making, language and memory – carry out complex computations all by themselves. The secret appears to lie in dendrites, the branch-like structures around a neuron that carry signals from other neurons to the cell's main body. The dendrites are studded with synapses, the contact points between neurons, which pepper them with incoming signals.

We had known for some time that dendrites can modify incoming signals before passing them on. But in a 2020 study, Poirazi and her colleagues at Humboldt University of Berlin found that a single human dendrite can carry out a computation that takes a neural network made up of at least two layers of many artificial neurons to replicate. Moreover, when a group from the Hebrew University of Jerusalem tried to train an AI to mimic all the computations of a single biological neuron, it required an artificial neural network five to eight layers deep to reproduce all of its complexity.

Could these insights point the way to more ›



MICHAŁ BEDNARSKI

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powerful, flexible AIs? Both Poirazi's group and researchers from AI company Numenta published studies in October 2021 suggesting that the properties of dendrites could help tackle one of deep learning's most debilitating problems – catastrophic forgetting. This is the tendency of artificial neural networks to forget previously learned information when they learn something new. Using more complex artificial neurons seems to get around this by allowing different regions of the network to specialise at different tasks, says Poirazi.

Flexible thinking

"You have smarter, smaller units, so you don't really need the entire network to learn," she says. That means previously learned information in other areas of the network doesn't get overwritten. Poirazi suspects this could also make AIs more flexible. By breaking problems down into smaller chunks that are stored in different parts of the network, it may be easier to recombine them to solve new challenges that an AI hasn't seen before.

Not everyone is convinced this is the best way forward. When Blake Richards at McGill University in Canada and his colleagues added dendritic complexity to their neural networks, they saw no performance gains. Richards has a hunch that dendrites are simply evolution's answer to connecting billions of neurons within the space and energy constraints of the brain, which is less of a concern for AIs running on computers.

For Richards, the key thing we need to tease out is the "loss function" used by specialised circuits in biological brains. In AI, a loss function is the measure that an artificial neural network uses to assess how well it performs on a task during training. Essentially, it is a measure of error. For instance, a language AI might measure how good it is at predicting the next word in a sentence.

If we can determine what a particular brain circuit is striving towards, we could establish a relevant loss function and use this to train a neural network to aim for the same goal, which should, in theory, replicate the brain function. Richards has tentative evidence of how this might work. In June 2021, he and colleagues from McGill University and AI company DeepMind showed that a single neural network trained using a loss function could replicate the two distinct pathways the visual cortex uses to independently determine what an object is and where it is.

By repeating this process for the many specialised networks in the brain, Richards thinks we could piece together the key components that make humans such versatile thinkers. "I suspect it'll have to be more modular," he says. "We'll want something that doesn't look radically different from the brain in some ways."

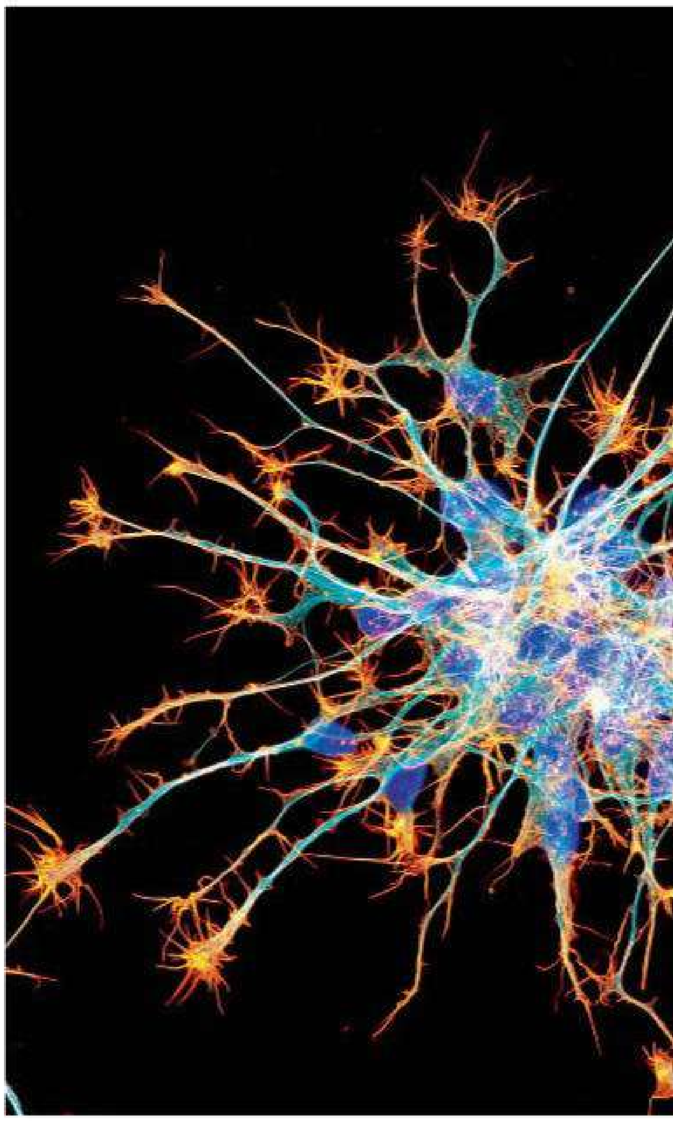
One brain area that could be crucial to advancing AI is the hippocampus, says Kimberly Stachenfeld at DeepMind. Stachenfeld is trying to understand how neurons in this region help the brain organise knowledge in a structured way so it can be reused for new tasks. "It allows us to make analogies with the past, to reuse information in new settings and be very dynamic and flexible and adaptive," she says.

It is possible to pull more general insights out of neuroscience to advance AI too, says Jeff Clune at the University of British Columbia, Canada, and Californian firm OpenAI. Thinking about catastrophic forgetting, Clune became fascinated by the brain's neuromodulatory system, in which certain neurons release chemicals that modulate the activity of other neurons, often in distant brain regions.

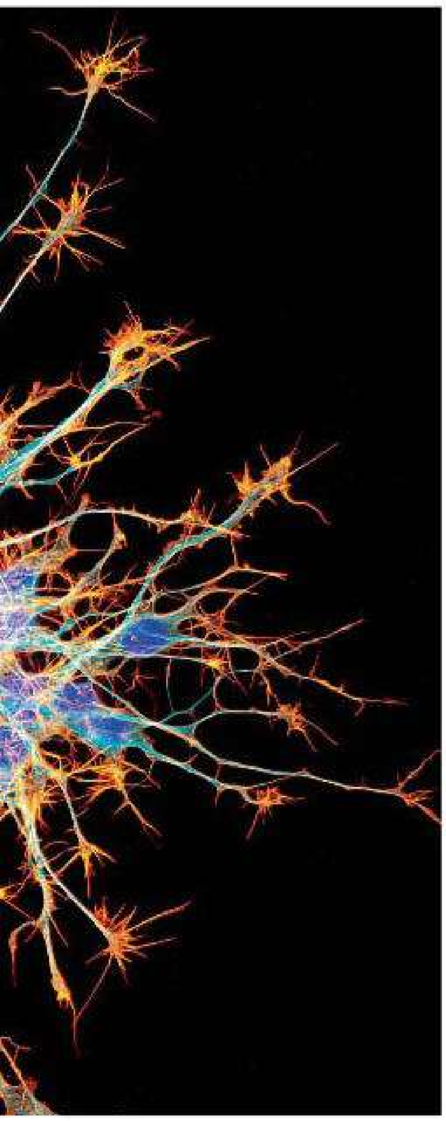
He and his colleagues realised that the ability to turn learning up or down in separate parts of their artificial neural network could help with continual learning, by allowing different regions to specialise at different tasks. They didn't try to build a replica of the neuromodulatory system. Instead, they trained one neural network to modulate the activity of another, switching regions of the second network on and off so it could learn a series of tasks without forgetting previous ones. "We weren't terribly faithful to the biology, we just took the abstract idea," says Clune. "When you're trying to do bio-inspired work, you want to get all, and only, the ingredients that will really move the needle."

But some insist we should take abstraction further, focusing not on replicating the brain's nuts and bolts, but the higher-level mental processes involved in gaining knowledge and reasoning about the world: a top-down rather than a bottom-up approach. Gary Marcus is the standard-bearer for this perspective.

Despite impressive progress, says Marcus, neuroscience can tell us very little about how the brain achieves higher-level cognitive capabilities. More importantly, the brain is an ad hoc solution, cobbled together by aeons of



> **"We want to emulate what the brain does. Psychology might be more useful for that"**



DR TORSTEN WITTMANN/SCIENCE PHOTO LIBRARY

Researchers are trying to copy the complexity of real brain cells in AIs

haphazard evolutionary experiments. "The brain is actually really flawed," he says. What we want is to emulate what it does, regardless of how it is put together. "In some ways, psychology might be more useful for that."

Psychology has some clear and well-validated models of the cognitive processes behind intelligence. Take the principle of compositionality, the idea that we understand things in terms of their parts and the relationships between those parts. This underpins reasoning in humans, says Marcus, but has proven difficult to implement in artificial neural networks.

There are ways to implement such principles in machines. The basic idea, known as symbolic AI, was the dominant approach to AI in the second half of the 20th century. It builds on cognitive theories describing how humans think by manipulating symbols. We use the word "dog" to refer to a real-world animal, for instance, and we know that the + sign means add two values together.

For engineers, creating symbolic AIs involves generating structured ways to represent real-world concepts and their relationships as well as rules about how a computer can process this information to solve problems. With chess, for instance, engineers encode possible configurations of pieces, the moves each can make and rules about which moves will help win the game.

Chess is one thing. Unpicking all the variables and relationships that govern most real-world problems is a different matter. That is why symbolic AI fell out of favour in the late 1980s, setting the stage for the rise of data-driven deep learning. And yet it turns out that many of symbolic AI's strengths overlap with the weaknesses we have discovered in deep learning. Now, there is growing interest in combining the two.

Hybrid intelligence

So-called neuro-symbolic systems attempt to retain deep learning's ability to learn from new experiences, while introducing symbolic AI's ability to do complex reasoning and draw on pre-existing knowledge. "There must be some way of bringing the insights from these two traditions together," says Marcus.

One possibility was outlined at a conference in January 2021 by IBM's Francesca Rossi and her colleagues. Their proposal builds on the idea outlined by Daniel Kahneman in his best-selling book *Thinking, Fast and Slow*, which splits the human mind into two broad modes of thought. System 1 is fast, automatic and intuitive, and responsible for rapidly making sense of the world around us. System 2 is slow, analytical and logical, and controls our ability to reason through complex problems.

The group combined this idea with AI pioneer Marvin Minsky's "society of mind" theory, which postulates that the mind consists of many specialised cognitive processes that interact to create a coherent whole. The result is a conceptual system made up of multiple components specialised for different system 1 and system 2 tasks.

As in the human mind, system 1 agents kick in automatically as soon as the AI is set a task. But an overarching "metacognitive" module then assesses their solutions, and if they don't work, it pulls in a more deliberative system 2 agent. It doesn't necessarily matter which technology is used for individual components, says Rossi, but in their early experiments, the system 1 agents are often data-driven, while system 2 agents and the metacognitive module rely on symbolic approaches.

There is considerable resistance to the revival of symbolic approaches. In a recent paper, the three pioneers of deep learning – Geoffrey Hinton, Yoshua Bengio and Yann LeCun – made it clear they think system 2 capabilities should be learned by neural networks, not built by hand.

The argument, says Richards, is that humans aren't smart enough to build symbol systems that capture the complexity of the real world. The focus therefore should be on working out how to encourage a network to develop in ways that mimic the brain's development of high-level cognitive abilities. "We are not smart enough to hand-engineer this stuff," he says. "And you don't have to be. You can just let the neural network discover the solution."

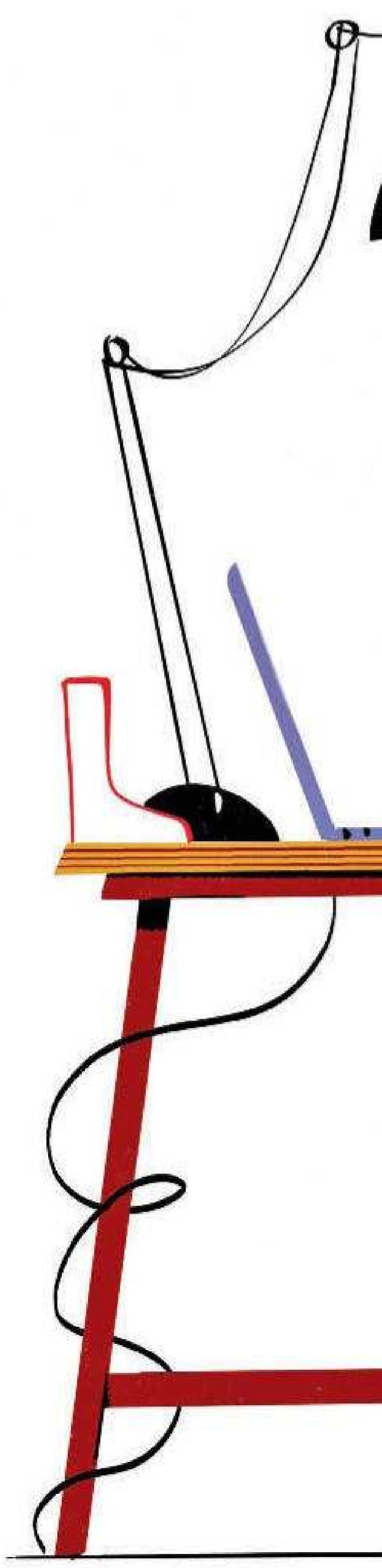
We still don't know how to steer one to do so, though. Brenden Lake at New York University and Meta AI Research says a promising approach is to build symbolic models that replicate aspects of human intelligence and then try to replace as many components as possible with data-driven machine learning. "You can take symbolic models that have been really successful and then see what are the minimal, critical symbolic pieces that you need in order to explain its abilities," he says.

Ultimately, there are probably benefits to both the top-down and bottom-up approaches, says Konrad Kording at the University of Pennsylvania. Studying human behaviour can give us clues about the abstract cognitive processes we need to replicate in thinking machines, he says, while fundamental neuroscience can tell us about the building blocks required to build them efficiently.

But perhaps the biggest contribution either approach can make to AI is cultural, says Kording. AI research today is driven by benchmark challenges and competitions, which promote an incrementalist approach. Most advances are achieved by simply tweaking the previous state-of-the-art model or training it on more data or on ever bigger computers.

Those who study human intelligence bring a different perspective to the field. "They're driven by a will to understand instead of a will to compete," says Kording. In the long run, that attitude may prove more valuable than any details about how our brains and minds work. ▮

Edd Gent is a freelance journalist based in Bangalore, India



Are you sitting comfortably?

If you worry that slouching is causing you long-term discomfort, think again. It is time to rewrite the rules of perfect posture and find the real cause of our aches and pains, asks **Alison George**

HEAD up. Shoulders back. Sit up straight. No doubt you heard these commands as a child, and they have probably prompted you to sit or stand a little straighter right now. With UK adults spending half of the day in front of a screen, and millions experiencing backache, you would be forgiven for linking the two and being as concerned about your posture as your parents.

"The public genuinely think that it's dangerous to slouch. We have done multiple studies in different countries about this," says Kieran O'Sullivan at the University of Limerick, Ireland, who specialises in back pain.

To a legion of slouchers, then, it may come as a surprise to hear that clear evidence of what constitutes good posture and whether your deportment is harming you is only just coming to light. The revelations are overturning many common assumptions. New studies are unravelling the link between posture and pain, highlighting the problems that we really should care about and even identifying ways of sitting and standing that can boost our mood. So, sit back (slouch if you want) and prepare to have your ideas about posture turned on their head.

The ideal posture is something that humans have been talking about since at least the Ancient Greeks – think of all those statues with athletic-looking physiques, standing upright, back straight. "Written evidence in the West begins with the Greeks, but in my fantasy, I can see some Neanderthal mother yelling at her kids to 'stand up straight and stop looking like those *Homo sapiens* across the valley'," says Sander Gilman at Emory University in Atlanta, Georgia, the author of *Stand Up Straight! A history of posture*.

What exactly is ideal though? In part, our views of posture are guided by our culture. "A lot of what we think of as good posture is about aesthetics and ideas about what is deemed elegant, attractive, interested or motivated," says O'Sullivan. "My research shows that women are more critical about their sitting posture than men, maybe reflecting greater societal expectations of appropriate posture among women."

How we hold our body is also intimately linked with ideas about health. We associate a fit soldier as upright-looking and a physically weak, dying person as hunched over, says Leon Straker at Curtin University in Perth, Australia.

Yet from a medical standpoint, ideal posture is a hazy concept. Physiotherapists generally advise that the optimal posture is a balanced one, which is comfortable, stable and symmetrical and doesn't overstrain any specific muscle or joint. But what does this mean in practice? Should we aim to be as straight-backed as possible, in the perfect plumb line posture that your parents probably had in mind when they told you to sit up straight when you were younger?

It is difficult to say. Our spine is naturally S-shaped when viewed from the side, with a slight inward curve in the lower back (the lumbar region), an outward curve in the upper trunk (the thoracic region) and another inward curve at the neck (the cervical region). All of us have different degrees of curvatures, depending on our genetics, life experience and habits. Our posture changes as we age, too, becoming more stooped.

All of which makes it difficult for medical experts to come to an agreement on perfect posture. One study led by O'Sullivan, for example, asked physiotherapists to rate the best seated position, giving a range of nine

ANTONIO SORTINO

options, from sitting bolt upright through to a pronounced slump with the chin jutting out. Around half thought that an upright lower back with a more relaxed upper trunk was best, but about a third thought that a forward tilt from the hips with the spine held in a straight line was optimal.

What's more, while we all have views on what constitutes good posture, we rarely live up to them. This was demonstrated last year by a team of researchers led by Vasileios Korakakis at the Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar, in a study of 100 healthy people. Most naturally sat in a mild slump, but when asked to adopt an optimal sitting posture, all sat up much straighter – the women more so than men.

But is slouching actually causing us any harm? Search online and you will find numerous websites outlining how "bad" postures lead to neck, shoulder and back pain, along with techniques to fix them. There is even a UK National Health Service web page dedicated to common posture mistakes and the problems they can cause.

If only things were that simple. For a start, although sitting with your neck or spine at an odd angle can cause temporary muscle soreness due to overactivity in certain muscles or a decrease in oxygen to tissues, the link between posture and longer-term pain is highly contentious.

> "A lot of what we think of as good posture is about what is deemed elegant and attractive"

Pain in the neck

While some, often smaller, studies do show an apparent link, larger, more rigorous analyses don't. "There's very little evidence that our regular posture can predict whether we're going to get chronic pain," says Straker.

Other researchers go even further. "It's not that there isn't much evidence to link bad posture with causing long-term pain, there's none," says O'Sullivan.

For instance, a 2021 review of 653 relevant papers by researchers at Monash University in Melbourne, Australia, concluded that there was no reliable evidence to determine that specific driving postures were associated with lower back pain. Meanwhile, a 2017 study by researchers at the University of Southern California comparing 67 people with shoulder pain against 68 people who were pain free, found no difference between the habitual shoulder posture of the two groups. The list goes on.

For Karen Richards, also at Curtin University, the lack of evidence linking posture and pain became apparent after a number of parents brought their teenage children into her clinic with concerns over their posture. None of them had pain, says Richards, and it became clear that there wasn't much evidence on the possible pitfalls of their posture to give her cause to intervene.

To address this academic void, Richards conceived a project in which 686 17-year-olds were assessed. All were part of a long-term investigation of the role that early events have on later life. Each person was categorised for their natural sitting neck posture – upright neck and body; slumped chest with head jutting forward; erect chest with forward head; and an intermediate position with a gentle spinal curvature – as measured by body sensors. Five years later, the team recorded whether each participant had experienced neck pain that persisted for three months

Change your posture to change your mood

Long-term pain may not be an inevitable consequence of bad posture (see main story), but the notion that "good" posture is beneficial isn't completely ill-founded. Certain postures can lift your spirits.

An awareness of a link between our body and our emotions goes back to the 19th century, when philosopher William James suggested that we don't laugh because we are happy, rather we are happy because we laugh.

This idea is now known as "embodied cognition", where the body influences our thoughts. For instance, when you meet a loved one, your heartbeat may increase and you might feel their skin against your own as you embrace. The brain, which is constantly assessing changes to information from the outside world and from our internal body, combines this new data and conjures up the appropriate emotion. Only then do we consciously perceive the feeling of love, or joy.

Several experiments support this idea. For instance, studies by Elizabeth Broadbent at the University of Auckland, New Zealand, have shown that the posture of people with depression tends to be more slumped than that of people without the condition. But the effect goes both ways. Her team randomly split people without depression into two groups, using physiotherapy tape to strap their back into either a slumped or upright seated position. The participants then gave a speech. Afterwards, the upright group not only reported a more positive mood, but were less stressed as measured by blood pressure.

Walking with a more upright posture may make you feel happier

SOLSTOCK/GETTY IMAGES

Another experiment, by Johannes Michalak at Witten/Herdecke University in Germany and his colleagues, used biofeedback to manipulate people's style of walking on a treadmill.

Students were initially shown positive and negative words and asked how well each word described them. They were then guided into walking in a style that resembled that of someone who was unhappy or extremely happy.

These gaits were based on experiments showing that people who are sad tend to walk with an increased sideways body sway, decreased arm swing and have a more bent over posture than those who are happy.

At the end of the study, the participants were given a surprise test – to remember as many words from the start of the study as possible. Participants recalled more negative words when walking in a style that resembled individuals who are sad than they did when walking with a happier gait. The researchers suggest that the walking style may have triggered a change in emotional state, which then affected memory recall.

within the previous year.

The results were surprising. For male subjects, sitting neck posture at age 17 wasn't a risk factor for neck pain at 22. For female participants, those who sat upright were actually more likely to have experienced prolonged neck pain, whereas more slumped postures were protective. The generic public health message to sit up straight to prevent neck pain needs rethinking, concluded Richards and her team. Richards thinks that the female subjects' neck pain could be a result of sustained, low-level muscle activation needed to maintain an upright position, a posture perhaps triggered by other factors such as anxiety.

Statue still

While the link between specific postures and long-term pain is unravelling, the way we sit and stand is still important, not least because it can affect your mood (see "Change your posture to change your mood", left). Furthermore, your posture might still lead to problems down the line – not necessarily because of how you position your body, but because of how long you stay that way. Many of us are becoming more sedentary. "Over time, we are becoming less active, at work and in our leisure time, and we see this in most countries," says O'Sullivan.

This means that whatever posture we are prone to, we are holding it for longer periods of time. And over the years, our bodies mould themselves to the shapes we hold them in. "The body responds to what we do with it, particularly for children and young adults," says Straker. "Bones are getting rebuilt every day, and they get rebuilt in response to the stresses we put on them."

Researchers strongly suspect that prolonged slumping could eventually have a permanent effect on the shape of our bodies. "My best guess is that if you spend an awful lot of time hunched over, then you're more like to be hunched over permanently," says Straker. The implications of this lasting shape change are unknown – the cumulative effect of decades of slouching in front of a screen haven't yet been studied – but some

researchers are concerned.

"We don't know yet what's going to happen to these kids who slouch all day long," says Wendy Katzman at the University of California, San Francisco. If you develop an excessive forward curve of the thoracic spine, "over time, you're going to lose the ability to inflate your lungs fully", she predicts.

If you are prone to sitting or standing in one position for too long, you can counteract the effect on your body by stretching and strengthening the muscles and ligaments that would otherwise become shorter and weaker as a result. Pilates and yoga can help you achieve this result. These kinds of exercises also help maintain the body's ability to sustain a full range of movement, something that concerns Straker and other physiotherapists far more than "poor" posture.

Strength and flexibility exercises can also counteract the pronounced stooping of the thoracic spine that affects 40 per cent of adults over the age of 65 (see "Stop the stoop", left). A severe stoop can seriously affect quality of life, for instance, by slowing down walking speed.

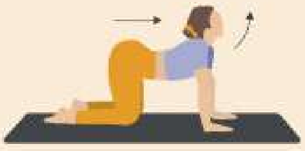
One thing that isn't helpful, says O'Sullivan, is forcing yourself to hold positions that are unnatural in an attempt to improve your posture. "When you ask people to sit 'properly' – in other words, straight – that just tends to make them sore and uncomfortable," he says.

This is one reason why some physiotherapists – who, as a profession, were once obsessed with "correct" posture – now think we should be far less concerned about our posture and instead focus on moving about more. "I would suggest worrying about it less and change posture more frequently. The best posture isn't the same for everyone," says Richards.

And that's a message the experts finally do agree on. "Don't worry about sitting posture, and don't hassle your kids about how they sit," says O'Sullivan. "Just make sure you move around lots in between your slouching." ▮

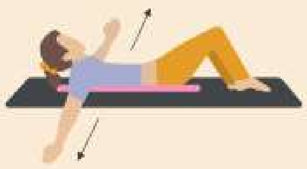
Stop the stoop

Muscle weakness, decreased spinal mobility and a gradual decline in our awareness of the position of our body in space all lead to a gradual stoop after middle age, which can sometimes become severe and debilitating. Research by Wendy Katzman, who studies physical therapy at the University of California, San Francisco, shows that a combination of strength and flexibility training can help you fight back.



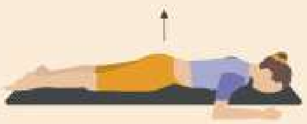
SPINAL FLEXIBILITY

Kneel on all fours, inhale, and arch your back, tipping your pelvis and chest forwards. Look up to the ceiling, then exhale and tuck your pelvis under, drawing your abdominal muscles towards your spine and tucking your chin towards your chest. This, also known as the "cat-cow" pose, helps maintain spine flexibility.



CHEST STRETCH

Lie on your back with your knees bent and a foam roller placed lengthways along your spine. Stretch your arms out to the sides. This allows the chest and front of the spine to stretch, along with associated muscles, ligaments and joints.



PRONE TRUNK LIFT

Lie face down, with your arms, head and shoulders in a W shape. Lift your upper trunk a few inches off the floor then relax. Aim for two sets of eight repetitions. This strengthens the muscles attached to the back of the spine.

A six-month programme of these types of exercises, three times a week, has been shown to reduce the curvature of the upper spine, says Katzman.

Alison George is a features editor at *New Scientist*

In from the cold

As ice and frozen soil around the world melts, potentially deadly microbes that have lain dormant for millennia are being released. How worried should we be? **Michael Marshall** investigates

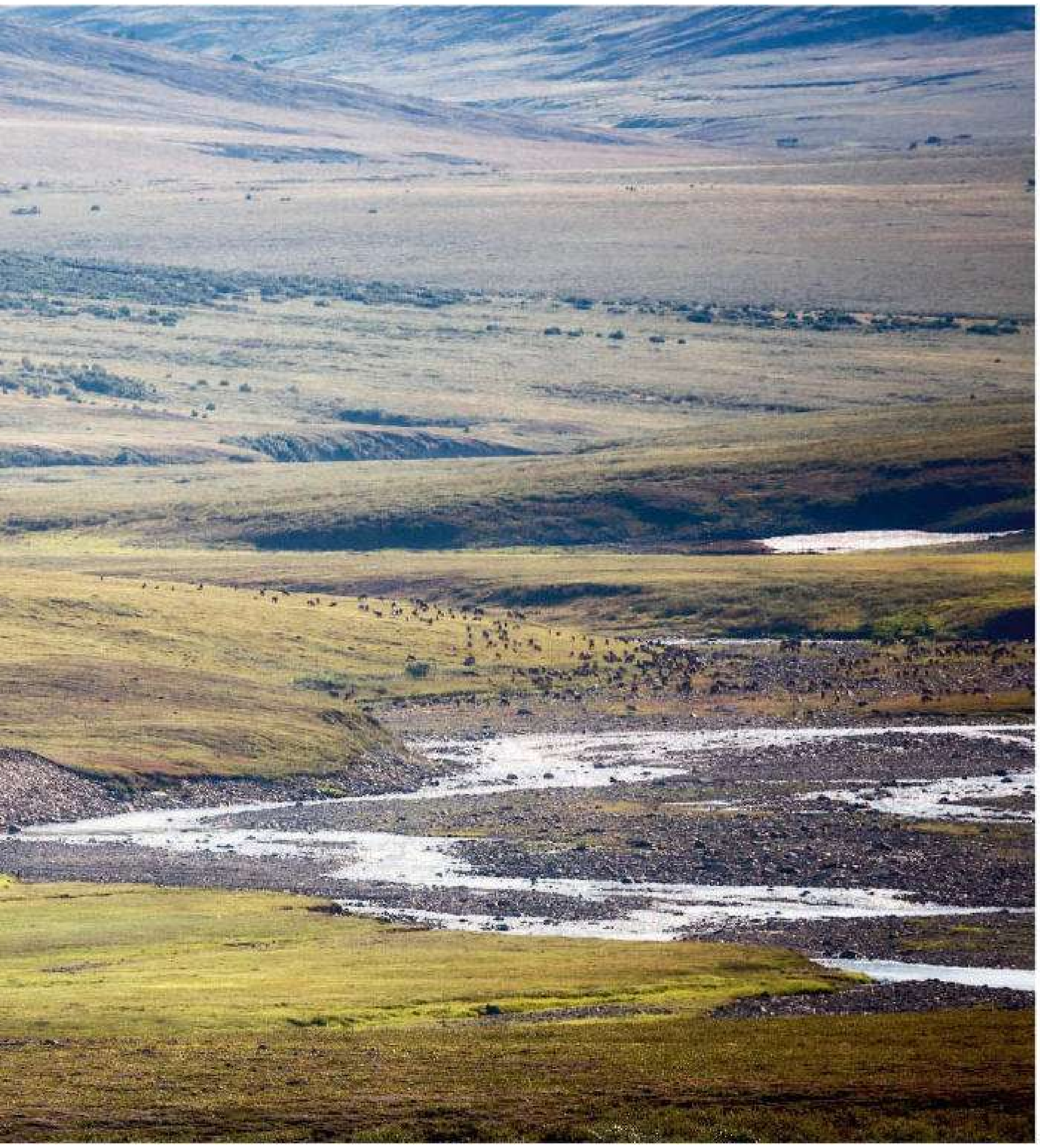
LEFT: ELENA SHCHIPKOVA/ALAMY; TOP RIGHT: ALEXANDER LUTSENKO/ALAMY

IN NOVEMBER 2019, the US National Academies of Sciences, Engineering and Medicine held a workshop to discuss an emerging disease threat. Not covid-19: they were a couple of months too early for that. Instead, they were trying to figure out what to do about microorganisms trapped in glaciers, ice sheets and permafrost, which will be released as the world warms and the ice thaws.

During the meeting, Alexander Volkovitskiy from the Russian Academy of Sciences recounted an alarming incident. It took place in 2016 on the Yamal peninsula on Russia's northern coast where local people herd hundreds of thousands of reindeer. That summer, temperatures were unseasonably warm and some of the permafrost thawed. The bacterium that causes anthrax – which had been present on the peninsula for over a century – emerged from the soil and spread like wildfire. Before the outbreak was brought under control, more than 2000 reindeer had perished. Dozens of people also caught the disease, including an unnamed boy who died.

This story could be a harbinger of what is to come. As Earth's icy regions thaw, long-dormant microbes will inevitably emerge. The organic matter in permafrost is teeming with them, and even glaciers and ice sheets aren't the pristine environments once imagined. How likely is it that these microbes – some of which have been trapped for millions of years – will defrost and come back to life? If they do, what risk could they pose to humans? Might we even be exposed to ancient diseases that once infected Neanderthals and Denisovans? These are the questions we need to answer if we are to combat this latent threat.

About 10 per cent of Earth's surface is covered with ice and snow. The great ice sheets of Antarctica and Greenland span 15.7 million square kilometres between them. And there are huge rafts of floating sea ice. Hundreds of thousands of glaciers slide imperceptibly slowly down mountainsides and valleys. Meanwhile, the northern hemisphere alone has 23 million square kilometres of permafrost, soil that stays below 0°C for at least two consecutive years, mostly in Siberia, the Tibetan plateau and the far reaches of North America. Climate change is melting it all. Greenhouse gas emissions have already warmed the planet by 1.1°C. In the Arctic, warming is at least twice and possibly three or four times that. Arctic sea ice is shrinking and will probably decline to less than a million square kilometres at least once by 2050. Glaciers are retreating ever further up their valleys. And the ice sheets of Antarctica and Greenland are slowly falling apart at the edges.



Melting permafrost in Russia's Yamal peninsula (left) has exposed nomadic reindeer herders (above) to anthrax

Anything stored in melting ice, snow and permafrost is going to come out. So we need to know what microbes are in there.

One of the first attempts to find out took place just over a century ago. The Australasian Antarctic Expedition of 1911 to 1914 was a difficult affair in which two team members died and a third had a mental breakdown. But the expedition's chief doctor, Archibald McLean, succeeded in growing cultures of bacteria, fungi and protozoa from Antarctic ice. Even when he dug more than 2 metres own into the ice, he found life. McLean described his findings in the journal *Nature* in 1918. With considerable foresight, he suggested that the microbes were carried to Antarctica on winds and fell to the ground in snowflakes. When they reach the icy surface, he wrote, "the frozen organisms… commence a new life-history".

Since then, it has become clear that snow and ice can contain thriving communities of microscopic life. For example, in 2013, Trista Vick-Majors at Michigan Technological University was part of a team that drilled into Lake Whillans, which lies 800 metres beneath the surface of the West Antarctic ice sheet. "I thought we were going to be lucky to measure anything," she says. "There was a lot more going on there than we expected." Subsequent studies revealed entire ecosystems of bacteria and other microorganisms with diverse lifestyles all living together, despite the cold and darkness.

> "We might even be exposed to ancient diseases that once infected Neanderthals"

Pathogens on ice

Perhaps we shouldn't be surprised: Lake Whillans is made of liquid water, even if it is in a rather extreme site. When temperatures are within a few degrees of 0°C, many microbes can survive. For example, on glaciers in the Andes mountains in South America, where there are trickles of water between the ice crystals, Pamela Santibáñez at the Ministry of Science, Technology, Knowledge and Innovation in Chile, has found multitudes. "I can see bacterial activity in between the snow and the ice," she says.

However, as you dig deeper into ice sheets – into layers that are thousands of years old and far colder than 0°C – life becomes sparser. Santibáñez and her colleagues also looked for microbes in the West Antarctic Ice Shelf Divide ice core, which contains ice laid down over 68,000 years. Concentrations of microbes varied over the millennia, with shifts following changes in the climate. What's more, microbes in older layers were badly damaged. "Cells that have been in the ice for 25,000 years or 30,000 years, at -30°C, they are in really bad shape," says Santibáñez.

This carries a reassuring message: although we can detect microbes in ice that is ›

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The quest for life's origin
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Neanderthal colds and Denisovan flu

Could melting ice and permafrost expose us to disease organisms that infected now-extinct ancestral human groups? It is a dramatic idea, but not an impossible one. Neanderthals and Denisovans were closely related to us and it is likely that early modern humans were afflicted by some of the same pathogens, including those that cause the common cold and cold sores.

A tiny quantity of bacteria or viruses in melting ice wouldn't pose a significant risk. The real danger would come if a well-preserved body thawed out of permafrost and released lots of infectious material. That seems unlikely. Although Denisovans lived in Siberia and Tibet, their known remains are very sparse and, to date, include nothing more substantial than a jawbone. Neanderthal remains are numerous, but they come mostly from far outside the permafrost zone. Besides, no bodies with preserved flesh have yet been found.

That said, we can't rule it out. In 2016, a mummified wolf pup was found in thawing permafrost in Canada, and it turned out to be 57,000 years old. Neanderthals are thought to have survived until around 40,000 years ago and Denisovans until about 50,000 years ago. So it is possible a frozen hominin corpse is out there somewhere waiting to emerge from the freezer.

millennia old, there are few of them and they aren't exactly thriving. This doesn't, however, mean that nothing survives. In a 2007 study, researchers managed to grow bacteria from Antarctic ice that was up to 8 million years old. Fortunately, those that endured weren't ones that make people ill. Indeed, bacteria that infect humans are adapted to live at our body temperatures, so it is highly unlikely that they would survive for long periods below zero.

The same is true for fungi. Some 300 fungi are known to be pathogenic to humans, including *Cryptococcus neoformans*, which can cause dangerous lung infections. Fungi have been found in ice, from Greenland and Svalbard in the north to Antarctica in the south, and in the slush left behind when glaciers retreat. What's more, ice from Antarctica has yielded fungi that can be grown in the lab. But again, the quantities are tiny and they weren't species that are dangerous to us.

This pattern holds for glacier ice too, even though it is often younger and less cold than ice sheets. "Glaciers are the cleanest places on this planet," says Lonnie Thompson at Ohio State University, who has spent decades exploring these rivers of ice. "When we're in the field, we drink the meltwater from those glaciers. To date, none of our field team has had any issues from drinking that water."

Viruses in the freezer

So it looks as if we needn't worry too much about such microbial life emerging from ice sheets and glaciers. But what about viruses, those tiny structures that are only ambiguously alive?

In 1999, researchers identified a virus that infects tomatoes and other plants in 140,000-year-old glacier ice from Greenland. Five years later, a second group suggested that ice might act as a reservoir for pathogenic viruses including influenza A, caliciviruses that cause gastroenteritis, and certain enteroviruses (the group that includes the polio virus). There was little evidence to back up this idea and other studies are more reassuring. And, although an analysis of very salty Arctic water found plenty of viruses, the majority specialised in infecting bacteria and posed no risk to people. Similarly, last year Thompson's group identified a range of viruses in ice cores from Tibet, where the ice was as much as 15,000 years old. The majority were infecting bacteria. "On the warmer glaciers, you can have microbes and viruses growing on the surface," says Thompson. The bacteria are species that can survive in the cold, and the viruses parasitise them. "It's an ecosystem."

Compared with bacteria, there have been far fewer studies of viruses in ice. But we do know that they are blown there by the wind, and also that viruses are only contagious when present in large numbers. Vick-Majors finds these facts heartening. "There could be a couple of human pathogens in that package of air that landed there," she says. "I just wouldn't expect there to be enough of them to be a threat."

Even if microorganisms being released from glaciers and ice sheets are unlikely to make us ill, they aren't completely innocuous. "They'll be going into river systems," says Karen Cameron at the University of Glasgow, UK. "They're going to be buried within build-up of sediments and organic matter in lakes and downstream fjord environments and near-shore environments." She has shown that meltwater from the Greenland ice sheet carries microbes far downstream, and that such microbes may well remain active in their new homes. Many of these organisms are rare, so they aren't well studied, and it is hard to predict what they will do. "We really don't have a sense of how the ecology is going to change and what are the consequences of that ecological change," says Cameron.

Nevertheless, at this point, you may be wondering why the US National Academies are worried about diseases emerging from frozen regions. The thing is, while ice is pretty safe, permafrost isn't. Organic matter such as soil is a much more congenial environment for pathogenic microbes, so permafrost is likely to contain all sorts of nasties. The 2016 anthrax outbreak in Russia is just one example. Human remains exhumed from frozen ground in Alaska have yielded the complete

SHUTTERSTOCK/MIZZICK

DENIS KOZHEVNIKOV/TASS/ALAMY

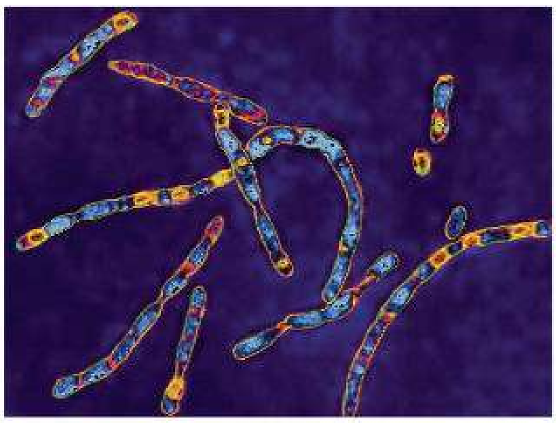
A melting glacier in Patagonia (left) and disturbed permafrost in Russia (below) may both yield disease-causing microbes

genome of the 1918 Spanish flu virus. A variola virus, related to the one that causes smallpox, was found in a 300-year-old Siberian mummy. And 700-year-old frozen caribou faeces turned out to contain genetic traces of two viruses, albeit not ones that infect us.

A class of microbes known as giant viruses have also turned up. In 2014, a team led by Jean-Michel Claverie at Aix-Marseille University in France found them in Siberian permafrost. These pithoviruses were different from most known viruses – much larger and with more elaborate genomes – and had remained intact in the ice for 34,000 years. They pose no danger to us, because they infect single-celled animals called protozoa. But their Stone Age origin raises an intriguing possibility that thawing permafrost could expose people to pathogens that infected now-extinct ancestral humans who once lived in the region (see "Neanderthal colds and Denisovan flu", left).

> "Researchers have grown bacteria from 8-million-year-old Antarctic ice"

The many pathogens in permafrost include anthrax bacteria



CAVALLINI JAMES/BSIP/SCIENCE PHOTO LIBRARY

Claverie's team has found other viruses too – or at least their genes – in studies looking at the genetic material of whole communities of organisms. "When we do metagenomics, we do see sequence signals corresponding to regular viruses," he says. Some of these are distinctly unwelcome, including poxviruses and African swine fever virus. "We see many classical viruses in terms of sequence," says Claverie. "But of course we don't try to revive those, because that would be dangerous and silly, and we don't want to be part of the next pandemic." Nevertheless, the real risk, he argues, is that dangerous viruses might accidentally escape from permafrost.

Parts of the frozen north are now being opened up, Claverie says. For example, in Siberia, opencast coal mines are sometimes dug close to people's homes. This entails removing layers of permafrost that can be hundreds of thousands of years old. "You don't know what is there," he says. This is all being done in the open, not in some biosecure laboratory. "Here is the real danger."

The National Academies agree. Delegates at the 2019 meeting concluded that we need increased disease surveillance in the Arctic to spot any outbreaks as quickly as possible and nip them in the bud. This is basic public health practice, but the challenge will be to get the systems up and running in remote areas, where the Indigenous people are sometimes suspicious of Western medicine.

For most of us, the thing to do is to keep this in perspective. The danger is real and needs dealing with – but it isn't likely to herald the end of the world. "I don't think that the current thinking is that some global pandemic is just going to thaw out from the Arctic and spread around the globe," says Vick-Majors. "But it's certainly a threat to northern communities." People living in the Arctic and in places such as Siberia are already seeing their environment melt around them. Now, they face the additional threat of deadly infections. Unless we take action, the 2016 anthrax outbreak could be the first of many. ▮

Michael Marshall is a freelance science writer based in Devon, UK

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Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

The science of cooking

Great balls of frozen fire

If you want to create some crowd-pleasing culinary surprises, bring some fundamental physics to the table, says **Sam Wong**

Sam Wong is assistant news editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

400 grams of ice cream
2 egg whites
75 grams crushed cornflakes
Half a teaspoon of cinnamon
2 litres vegetable oil, for frying

The science of cooking appears every four weeks

Next week

Stargazing at home

WHEN cooking food, we need heat to diffuse from the outside to its centre. If we want food to be evenly cooked throughout, this can be a problem: by the time heat reaches the centre, the outside may be overcooked. But in some cases, we can use the slow diffusion of heat to our advantage, to create foods with a surprise in the middle.

One example is a molten chocolate cake, aka a chocolate fondant. Essentially, this is an undercooked cake. The key is to bake it just long enough so that the outside is firm while the centre remains liquid.

But exactly how long should that be? An equation can give us an idea. The teachers at Harvard University's science and cooking class use the molten chocolate dessert to demonstrate how we can model the diffusion of heat using the equation $L = \sqrt{4Dt}$, where L is the distance heat travels in centimetres, t is the time in seconds and D is the heat diffusion coefficient, a measure of how fast heat travels through a given substance.

For water, D is 0.0014 cm^2 per second. Since most foods are largely made of water, we can use this value to approximate how quickly heat will move through many types of food.

Let's say that a chocolate cake is cooked for about 12 minutes (720 seconds) in a ramekin 8 cm wide. The equation tells us that the heat will travel about 2 cm through the batter in this time, giving us a nice thickness of solid cake on the outside and a decent molten core.

STOCKFOOD/BAYSIDE

In their book *Science and Cooking* – touted as a place where "physics meets food" – the Harvard trio of Michael Brenner, Pia Sörensen and David Weitz explain how to make an even more impressive dessert, similar to the one pictured, by covering a ball of ice cream in a thin coating and deep-frying it for just long enough to cook the outside while keeping the ice cream frozen.

Their recipe has a cooking time of about 15 seconds, during which our equation predicts that heat will travel 0.3 cm through water. But this recipe uses whipped egg whites to coat the ice cream. Like other foams, it is a great insulator and so should give the ice cream excellent, if brief, protection from the heat.

To give this recipe a try, scoop your ice cream into four 100-gram balls, place on a tray and put them back into the freezer for an hour. Whisk the egg whites until foamy. Then, separately, mix the crushed cornflakes and cinnamon. Roll the ice cream balls in the egg whites, then in the cornflakes.

In this time, the outside of the ice cream balls will already have started to warm up, so they need to go back into the freezer for a couple of hours to ensure they are completely frozen before frying. After this, heat your oil to 190°C in a large saucepan or deep fryer. Fry the balls, one or two at a time, for 15 to 20 seconds, then drain on paper towels before serving. ▮

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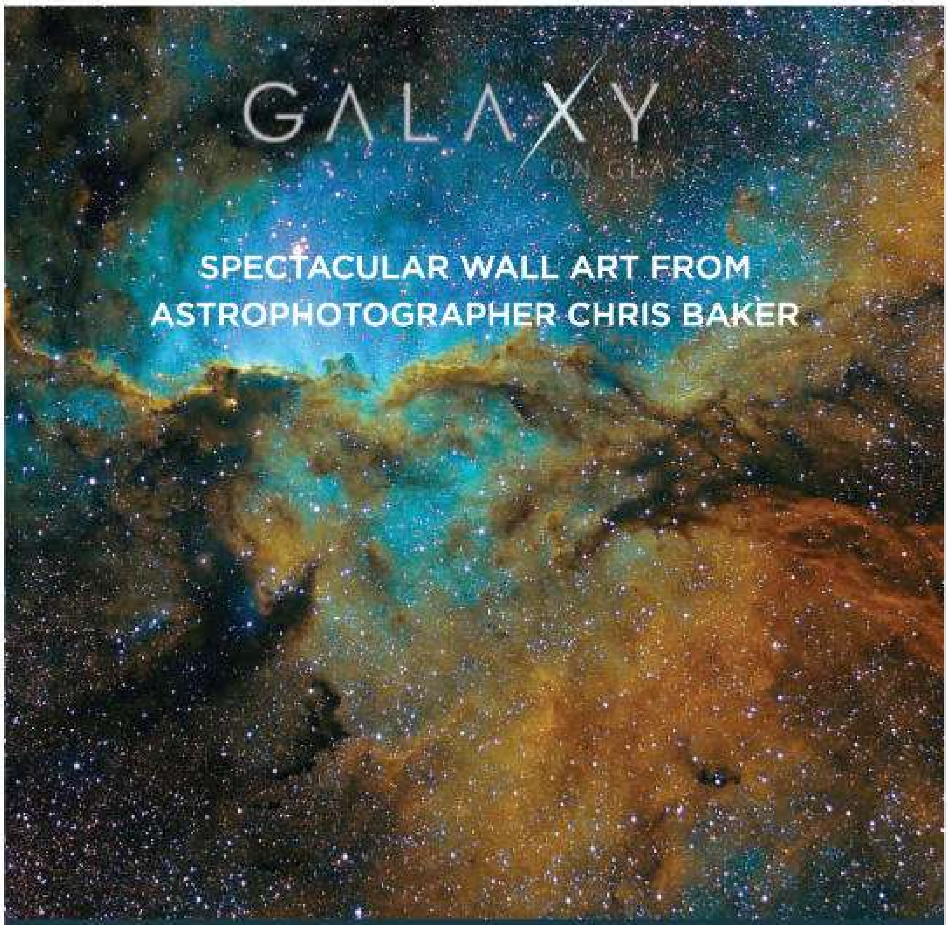

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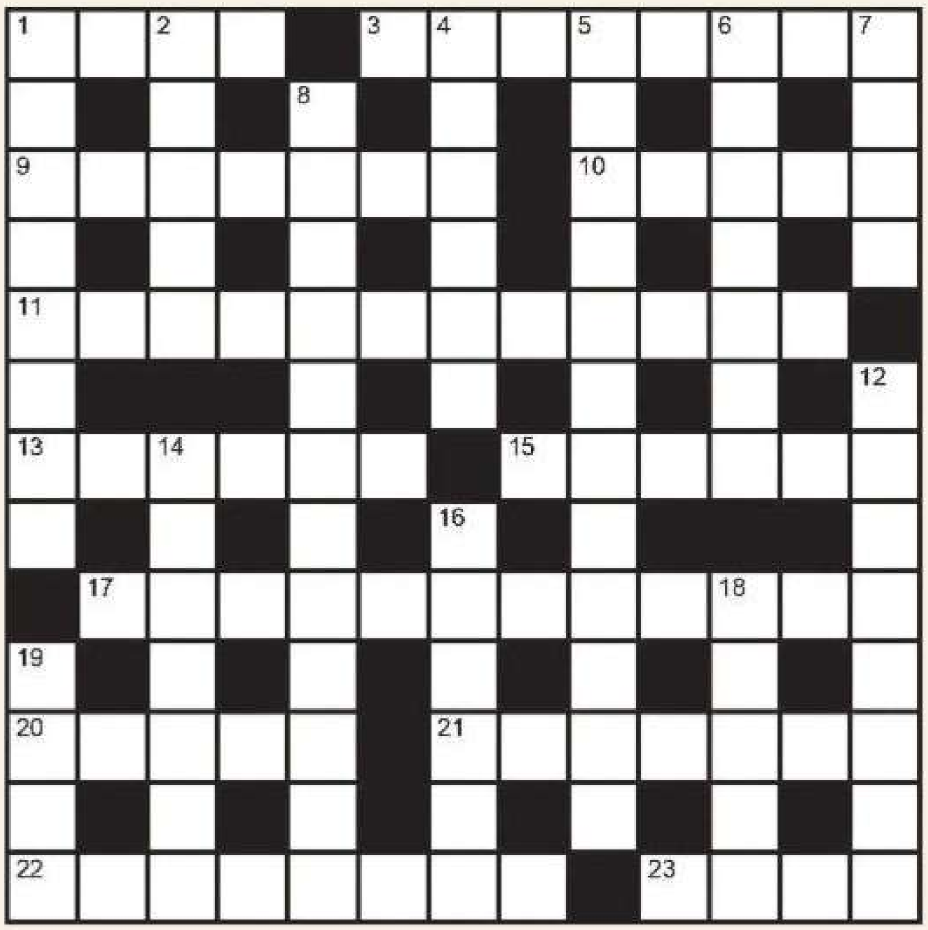


Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Gannet is regular subject for 3 Across (4)
3 One owl is sad for late biologist (1,1,6)
9 Little Rod the amphibian (7)
10 Put forward message about India (5)
11 Lacking evidence, nice US fiction gets rewritten, losing nothing (12)
13 Cleans doctor's clothes (6)
15 Recording equipment approached deity (6)
17 Emulsifying sauce with gravity, covering cat with case of emulsion (12)
20 To package blood types is forbidden practice (5)
21 Inhabitants of rented property or very small colony? (7)
22 Changed appearance of your head with light after break (8)
23 Expert overcomes new skin condition (4)

DOWN

1 Obvious statement supporting Pacino, perhaps, showing selfless behaviour (8)
2 Daily fluctuations of initially terrible concepts with no answer (5)
4 Canoes designed for large bodies of water (6)
5 Consequences of demon sitting on lithium ions with positive charge (12)
6 Possess ileum, to some extent, like a barnacle (7)
7 Record private school's rise (4)
8 3 Across's field of study is cool – boy, I go wild! (12)
12 Generosity shown by European leader supporting big ship (8)
14 Shape of Greek character on mass transportation (7)
16 Insect on table, dropping a bit for another insect (6)
18 Type of bond from ancient Greece (5)
19 Vermin ascend to heavenly body (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #139

1 Which type of coal has the fewest impurities: bituminous, lignite or anthracite?

2 The fossil AL 288-1 is better known by what name?

3 The idea that the number of transistors in a dense integrated circuit doubles roughly every two years is known as what?

4 Which organic compound was first isolated in 1838 by French chemist Anselme Payen?

5 What is the theoretical maximum size of a star's radius for a given mass called?

Answers on page 55

Puzzle

set by Howard Williams

#155 Mother Hubbard

Ada Hubbard loves creating riddles and takes every opportunity to pose them. She occasionally includes her daughter Betty in her brain-teasers.

When someone recently asked for Ada and Betty's ages, Ada gleefully supplied a riddle instead: "I am five times as old as Betty was when I was as old as Betty is now. When Betty is as old as I am now, then I will be 77."

How old are Ada and Betty?

Solution next week

Red rainbow

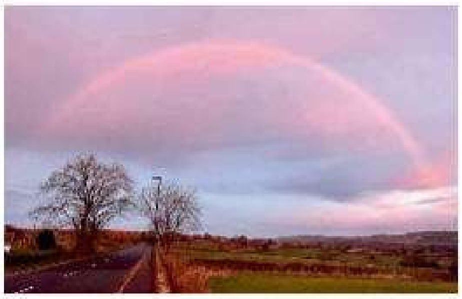
My friend spotted a strange red-only "rainbow" just after sunrise (pictured below). There was no rain, so what caused this?

Daniel Bellhouse
Leeds, UK
Red rainbows form in the same way as the usual multicolour ones, from light reflecting off the rear internal surface of water droplets in the atmosphere.

However, during sunrise and sunset, rays from the sun travel a longer path through the lower atmosphere. These rays are scattered by air molecules and dust. Shorter-wavelength blues and greens are scattered the most, so the remaining light is richer in longer-wavelength reds and yellows.

As the majority of the transmitted light is now in the red spectrum, this is the light seen reflected back from the water droplets, resulting in an almost exclusively red rainbow.

This mechanism is also the cause of beautiful red sunrises and sunsets.



Richard Swifte
Darmstadt, Germany
Rainbows with a red or pink hue are ordinary rainbows that happen to occur when the sun is low in the sky and appear redder than when it is higher up.

As for the absence of rain, it may not have been raining at the place where this photograph was taken, but the picture shows some clouds in the sky.

There was probably a localised shower some distance away in front of the photographer, with enough rain to produce the rainbow.

GUY BELL/SHUTTERSTOCK

What exactly is going on to make some music tug at the heartstrings?

This week's new questions

Mood music **I am a big fan of classical music. Why does some music evoke certain emotions in the brain, even if it doesn't have any lyrics?** ***Joseph Kostousov**, Calgary, Canada*

Green eating **We are told "eat your greens", but is there any reason why the green parts of plants are an essential part of our diet?** ***Tony Blake**, Adelaide, South Australia*

Young and loud

Babies and children make a lot of noise when they cry and shriek. Why do the young of other animals seem generally much quieter?

Vivienne Peters
Sydney, Australia
Young humans emit their compelling cries to obtain proximity to their caregivers, who then provide food, protection and reassurance. Babies aren't mobile for about nine months after birth, so they need an effective alternative method of summoning help to optimise their survival in infancy.

In human evolutionary history, perhaps babies and young children who were less vocal received less care. Conversely, caregivers who didn't feel spurred on by the sound of their offspring's cry may have been more inclined to disregard their needs. Along with the ability to smile and look cute, infants who could wail and scream to responsive and well-motivated caregivers must have increased their chances of survival.

If we look elsewhere in the animal kingdom for creatures that are equally immobile for a period of time after birth, the most obvious example is birds. Baby birds in a nest can also make a lot of noise, which prompts their parents to attend to them.

Both humans and birds grow up to be quite talkative as adults. Perhaps the development of human and bird language has a direct relationship to the level of helplessness seen in infancy. Young children certainly cry less and less as they become more mobile and learn to use words instead of cries.

Peter Holness
Hertford, UK
Humans are apex predators. Their babies tend to be safer than the offspring of other animals. Evolution has probably weeded out youngsters of other species that haven't learned to "shut up or get eaten".

David Muir
Edinburgh, UK
Babies and toddlers are loud, demanding attention so that they get the nurture and nutrition needed for successful development. As they are generally under the protection of their parents and aren't threatened by predation, human young can afford to be noisy. The offspring of other animals may make a tasty snack for predators when their parents are off looking for food, so they have to keep quiet to avoid unwanted attention.

When parents return with food, young birds can certainly be loud, as siblings compete for parental attention and associated sustenance. This short-term risk is worth taking as any individual advantage that results increases that bird's chances of passing on its genes later in life.

Nick and Loraine Baker
Colchester, Essex, UK
How does the questioner know that animal babies don't sound just as loud to their animal parents? (Here, we are referring to large animals and birds, rather than a wider range of organisms, many of which don't vocalise.)

A baby's cry contains frequencies to which the human ear is most sensitive; a puppy's little whines and whimpers probably sound annoyingly loud

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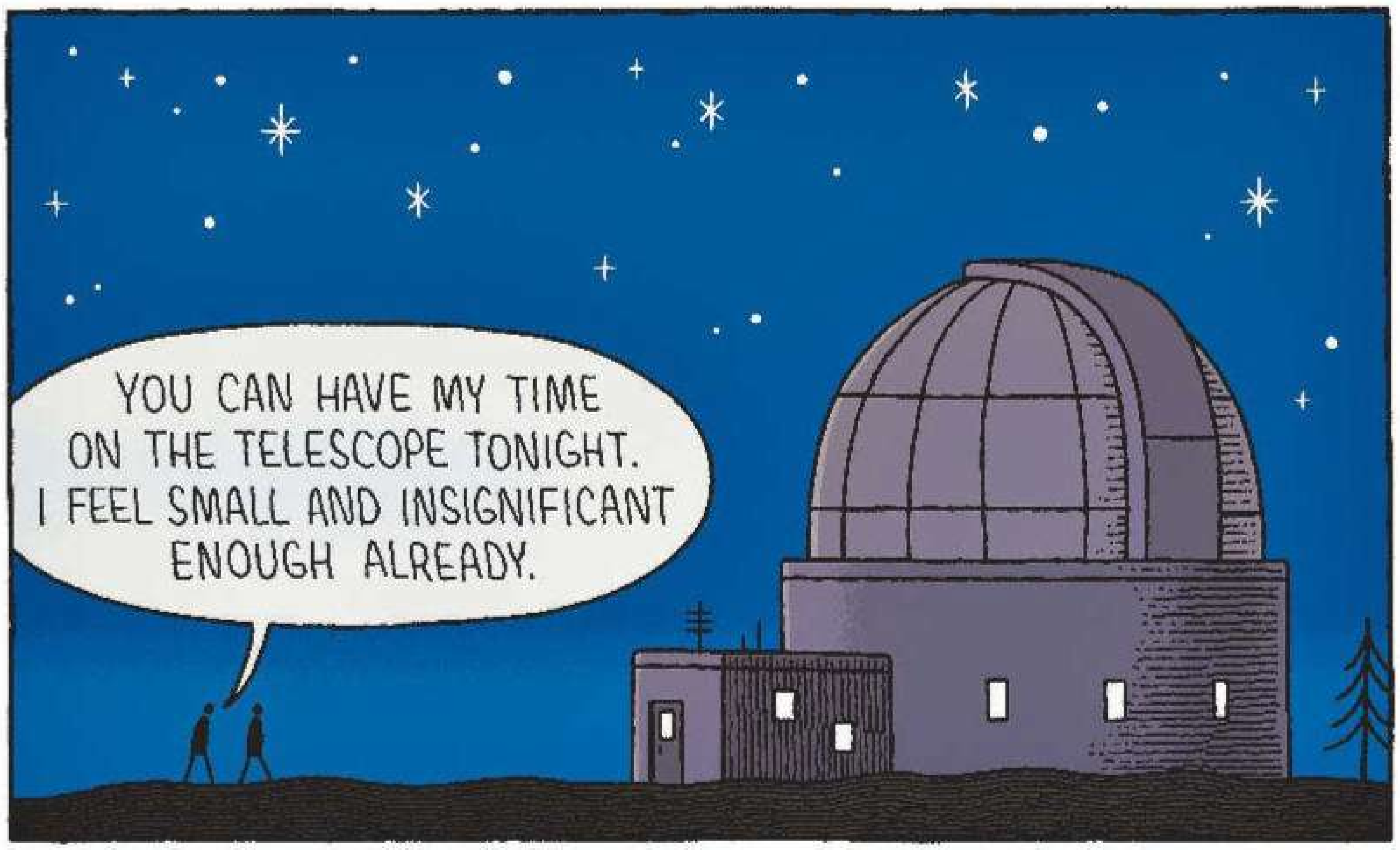
Tom Gauld
for New Scientist


YOU CAN HAVE MY TIME ON THE TELESCOPE TONIGHT. I FEEL SMALL AND INSIGNIFICANT ENOUGH ALREADY.

to its mother, due to her sensitive hearing in the higher frequencies.

Another reason why human infants can be so loud is because of certain domestic and social habits. In Western societies, babies are sometimes separated in a different room or even in the garden in a pram.

Right on time

I've been sent an appointment for 11.17am. Why do I perceive it as being more demanding of punctuality than 11.15 or 11.20, say? (continued)

Octavia Sheepshanks
London, UK
There is a more objective reason than discussed previously as to why certain times seem more demanding of punctuality.

We have a 60-minute hour thanks to the Babylonians. It is the best number for this purpose due to its large number of divisors: 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 and 60. A sexagesimal system gives a person the most options for how to divide their time each hour.

> "11.17am is one of the most demanding minutes past the hour to request an appointment, because 17 is a prime number"

Different times past the hour range in their degree of selfishness, in terms of requesting appointments. 11.30am, for example, is very considerate because it works with all the most the most common time divisions except 3 × 20 minutes: 2 × 30, 4 × 15, 6 × 10, 12 × 5, 30 × 2 and 60 × 1.

On the other hand, 11.17am is objectively one of the most demanding minutes past the hour to set an appointment, because 17 is a prime number and cannot be subdivided in any of those obvious ways.

This also applies to any of the other "selfish prime times": 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53 and 59 minutes past the hour.

It also explains why, when the time of an event is noted and it happens to be a prime number greater than five, you can be the most sure it is accurate and not rounded up.

Keith Ross
Villembits, France
I always asked my students to meet at 1.56pm after they returned from lunch rather than 2pm. It is simply a matter of accuracy: 2pm could be anything from 1.35pm to 2.25pm, rounded up to one figure, but 1.56pm can only mean between 1.55pm and a half and 1.56pm and a half.

Here in the south-west of France, most events billed for, say, 2pm won't start until 2.15pm.

John Henderson
London, UK
As a retired psychotherapist – a profession that yearns for scientific validation – I recall that we have a simple rule to understand this. A client that arrives early is anxious and one that arrives late is hostile. And those that arrive punctually? Clearly obsessional. ▮

Answers

Quick quiz #139
Answers

1 Anthracite
2 Lucy or Dinkinesh. The latter translates as "you are marvellous" in Amharic, an official language of Ethiopia, where the fossil originated
3 Moore's law
4 Cellulose
5 The Hayashi limit

Quick crossword #101 *Answers*

ACROSS 1 Hoover Dam, **6** Actin, **9** Rail gun, **10** Tuk-tuks, **11** Spawns, **12** Monorail, **14** Iota, **15** Automation, **18** Antiseptic, **20** Uric, **23** Mosquito, **24** Viagra, **26** Ribcage, **27** A priori, **28** Ernie, **29** Tau lepton

DOWN 1 Hiroshima, **2** Oxidant, **3** Engine, **4** Dune, **5** Metropolis, **6** Ark Royal, **7** Tsunami, **8** Nasal, **13** Outpatient, **16** Nictation, **17** Osculate, **19** Test ban, **21** Ragwort, **22** Pierre, **23** Marie, **25** Oahu

#154 Party line-up
Solution

There are 10 candidates.

In total, there are 21 "units" of the three virtuous traits to distribute among a certain number of people. Since we know, based on Tariq's observation, that one trait must be assigned to someone who already has two of them, then we can infer that the other 20 traits are assigned such that each person has two of them. It follows that there are 10 people, nine with two traits, and one with all three.

Sleep, perchance to diet

That April is the cruellest month has yet to pass peer review, but there is little doubt February is the shortest. Feedback considers this just as well. Some of our more southerly readers may be sunning themselves on the beach, but in our pre-Arctic stationery cupboard hole, we are just waiting for the winter murk to clear.

It is at this time of year, when we are thinking about getting fit for the bikini season and doing nothing about it, that we want to read, and not question too deeply, headlines such as our own "Getting enough sleep may lower the amount of calories you eat". The study in question, from a team at the University of Chicago Sleep Research Center, found that an extra hour's sleep at night allowed participants to cut their energy intake by 270 calories a day – "the equivalent of around three chocolate digestive biscuits", as the Press Association helpfully put it in its story on the research.

Why stop there? A comforting graph swims into our head of a rising line of hours not consuming calories, crossing over a falling line of calories consumed. The most effective weight-loss mechanism is surely to never get out of bed at all.

Getting up the nose

As we take some horizontal exercise, a PR puff is popped our way by a svelte, overslept-looking colleague with a straw hanging from their nose. "To inspire those who struggle to reach their recommended daily intake of water, air up is a world first in food technology that utilises retronasal smell to provide a zero-calorie, zero sugar, zero additive way to drink 100% pure water which tastes flavoured," we read.

Flavours "from Lime and Orange-Passionfruit to Cola and Iced Coffee" are created by using a special widget to inject bubbles of scented air into the previously 100 per cent blameless water. "We've revolutionised the way we drink water. You still have to use your mouth, but the taste has changed!" the company's website continues. A welcome release for those of us who had been attempting to discover flavour by snorting our water.

Twisteddoodles *for New Scientist*

WRITING FORMULAE ON WALLS IN MOVIES
OH WOW, YOU MUST BE SOME SORT OF GENIUS!
WRITING FORMULAE ON WALLS IN REAL LIFE
THAT MARKER PEN BETTER NOT BE PERMANENT
@twisteddoodles

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Smell my cheese

We note merely in passing a press conference held on 7 February by New York City's new mayor, Eric Adams, in which he claimed that people wouldn't be able to tell the difference between "someone hooked on heroin" and "someone hooked on cheese".

Entirely our experience too. Meanwhile, Adams's own claim that he eats a vegan diet has been called into question after he was seen eating fish. Given that phylogenetically there is no such thing as a fish, we can't rule out a plant-based variety. As to the cheese thing, as Twitter user Tyler Conway remarked, "let he who has not snorted grated parmesan off the countertop cast the first stone".

Sperm waving

If not cheese, SpermTree – "a species-level database of sperm morphology spanning the animal tree of life", recently described in the journal *Scientific Data* – promises some real, hard science.

What researchers get up to with descriptions of more than 4700 types of sperm, we hardly need to know. We are busy following an atavistic impulse by downloading the spreadsheet and reordering in descending order of sperm length.

Top of the list by some margin is the fruit fly *Drosophila bifurca*, with sperm over 5.8 centimetres in length when fully unfurled. This strikes us as a mite exhausting for an insect just a few millimetres long. We aren't surprised to learn elsewhere that this limits its output to a few hundred cells in its lifetime, an apparent limitation on its reproductive chances that has been dubbed the "big sperm paradox". This is clearly a sticky problem. Still, we are pleased to learn via a graph in the SpermTree paper that publications on sperm morphology are on the up and up.

Toast's flip side

"Dear Professor Feedback," Jonty Rix writes, warming the cockles of our heart. "As a social scientist," he continues, chilling our blood again, "I am perplexed (and a little disappointed) by the failure of your discussions about the landing outcomes of 'toast' to fully consider socio-cultural or post-materialist understandings of the possibilities."

We are beginning to regret reopening correspondence on the fate of falling buttered toast (8 January). But pray continue. "For example, the nature of upness seems a fundamental problem, as does a lack of a rich consideration of the numerous spaces in which toast is experienced, and of course our underlying definitions of toast and butter and the power relations inherent in their production and usage."

We nod uneasily, wary of saying the wrong thing. We hope some opening into this whole new metalevel of debate is given by Toby Bateson. He disagrees with our assertion, backed up with references, that toast will always land butter-side down in any universe that supports intelligent bipeds (29 January). "By simply making the toast twice as long it will rotate at half the speed and so will land butter side up," he writes. "The problem arises due to a fundamental flaw in the proportions of toast which can be adapted to solve the problem in any universe, regardless of table height and the intelligence of the bipeds who made the toast."

We're off to have a lie-down and burn some calories. ▮

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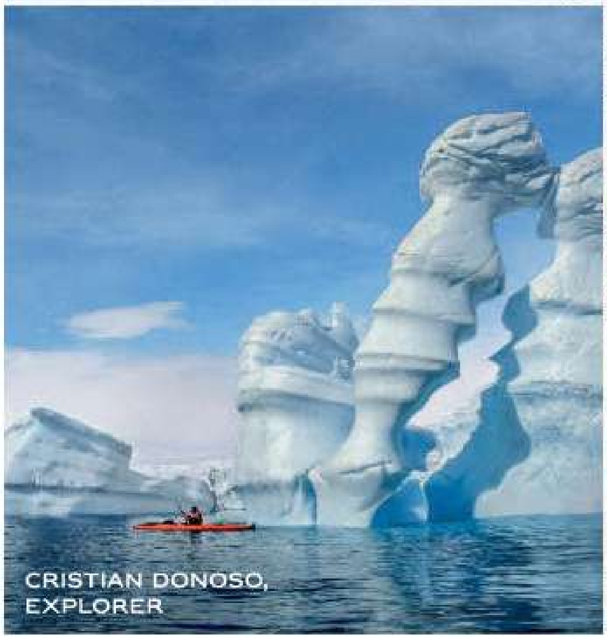

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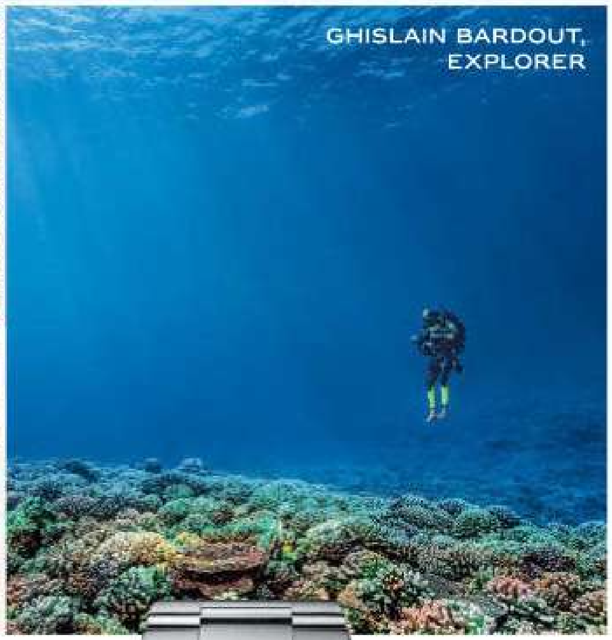

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OYSTER PERPETUAL EXPLORER II

WHAT DO THEY SEEK?

Explorers, adventurers, scientists. Men and women who always broadened the horizons, for all humankind to share. Rolex was at their side when they reached the deepest point in the oceans, the highest summits of the Earth, the deepest jungles and both poles. But now that we know, more than ever, that our world has its limits, why do they continue to venture out there, again and again? Certainly not for kudos, accolades, or an ephemeral record. What they truly seek is to understand more intimately how complex and delicate our planet is, to document its change and how together, we can affect it for the better. So as long as they need it, we will be at their side. Because today, the real discovery is not so much about finding new lands. It's about looking with new eyes at the marvels of our planet, rekindling our sense of wonder, and acting to preserve our pale blue dot in the universe… **Doing our very best for a Perpetual Planet.**

#Perpetual

ROLEX